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Combat Vehicle Command and Control System (CVC2): the development of the measures and evaluation techniques

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COMBAT VEHICLE COMMAND AND CONTROL SYSTEM (CVC^2): THE DEVELOPMENT OF THE MEASURES AND EVALUATION TECHNIQUES

by

Stephen McKinney

June 1993

Thesis Advisor: **Michael Sovereign**

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Combat Vehicle Command and Control System (CVC^2): The Development of the Measures and Evaluation Techniques

by

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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

This thesis examines the development of the measures for evaluating new tactical command and control (C2) systems such as the Combat Vehicle Command and Control System (CVC^2). Using those measures it discusses the various techniques available to evaluate CVC^2 and recommends the selection of one technique. In order to establish a strong foundation for understanding the needs of a battalion task force C2 system, the systems, processes, procedures, and standards available to the commanders are detailed. These assets are related to Orr's Combat Model to aid in the understanding of C2 at battalion level. The thesis concludes with the benefits, advantages, disadvantages, issues, and potential of CVC^2.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

The U.S. Army currently utilizes tactical command and control technology that has changed little since WW II for mounted operations. Battalion commanders and below still use FM radios, paper maps, and acetate overlays with grease pencils for graphic illustrations. In an effort to maintain an edge on the battlefield, the U.S. Army is introducing new command and control (C2) assets to aid the tactical commander in his C2 process. The introduction of these new technologies is designed to keep the U.S. commander's C2 cycle within that of his opponent's. The battlefield of the future will see the U.S.'s enemies with advanced technology giving them the ability to strike swiftly and reposition rapidly. Army commanders must be able to anticipate these actions, plan their own operations, and disseminate those plans to subordinate units so that they may be able to shoot first, fastest, and more accurately than the enemy and thereby retain their freedom of action.

One attempt to introduce the advancement of new technology at the tactical level is the Combat Vehicle Command and Control System (CVC^2). CVC^2's mission is to provide the maneuver force commander with accurate, timely information in order to make decisions, and assist him in preparing orders and supervising the order's execution. The

system must be responsive to vehicle mission requirements and effectively facilitate continuous planning, coordination, and assessment in every situation. An additional mission of CVC^2 is to aid vehicle commanders in identifying vehicles on the battlefield as friends or foes. By communicating and displaying friendly vehicle positions, CVC^2 will reduce the likelihood of incorrectly identifying a friendly vehicle as an enemy, thereby minimizing friendly-fire casualties (SSCVCC 1992). The primary goal of C2 as a commander's tool is the reduction of uncertainty and the control of battlefield information in an attempt to reduce chaos. A subsequent goal of improved C^2 is the delivery of increased combat power against the enemy. Consequently, throughout this thesis, CVC^2 is examined as part of the C2 process, not as part of a weapons system.

B. OBJECTIVE

This thesis will examine the development of the measures of effectiveness, performance, and force effectiveness and the techniques for evaluation of the Combat Vehicle Command and Control System using those measures. The specific tasks which an armor or mechanized infantry unit execute are scrutinized in the evaluation of CVC^2. Finally, the thesis will analyze the level of command, phase of battle, and battlefield operating system which benefit the greatest from the introduction of the

automated C2 system.

C. FORMAT

This thesis is organized into seven chapters: an introduction, a description of CVC^2, a discussion of C2 and its information requirements, an examination of specific combat tasks that tactical units must accomplish, an assessment of the evaluation of CVC^2, an explanation of the benefits of CVC^2, and a conclusion. Although C2 exists through the highest levels of command, this thesis will address only the C2 aspects at the battalion task force level and below.

Chapter I, the introduction, discusses the background for automated C2 and the objective and format of this thesis.

In Chapter II, CVC^2's capabilities, description, hardware components, and concepts are described. CVC^2's support of the commander and its relationship to IVIS (Intervehicle Information System) are also explained. This chapter outlines CVC^2's mission, operation, description, and the communication network it creates. The system's operation section highlights the network's users inside and outside the battalion, the reports and graphical overlays it can transmit, and its support of the three phases of battle. The system description explains the relationship with IVIS, the major hardware components and their descriptions, and

interface nodes both within and outside the battalion.

Communications, the system's critical link, serves as the medium to exchange information within the system. To understand the process, one must comprehend the inputs and outputs of the system. In Chapter III, the information required to support the command and control processes and systems available at battalion task force, company team, and platoon are discussed. The process and systems are then related to George E. Orr's Combat Operations Model to provide a better understanding of how each piece of the process and systems fit into the C2 puzzle.

Chapter IV examines several examples of the specific combat tasks for armor and infantry battalion task forces, company teams, and platoons and how they should be evaluated. The U.S. Army currently uses a series of Mission Training Plans (MTPs) based upon its Army Test and Evaluation Plans (ARTEP) to develop and evaluate the training of its units from the individual soldier to the highest echelons. Selected individual and collective tasks are outlined for the various specific missions. These MTP tasks build upon subordinate units as an archway builds upon its lower stones, being kept in place by the keystone. Although MTPs are created for units larger than battalion task force, this discussion is limited to battalion task force and below. The Army leadership has decided how units

should execute and train particular missions as outlined in the MTPs. These MTPs serve as the baseline for establishing the new measures to evaluate a new C2 system and determine how well the system can influence the commander's C2.

Using these MTPs as a baseline, Chapter V addresses the measures of effectiveness (MOEs), measures of performance (MOPs), and measures of force effectiveness (MOFEs) in evaluating the automated command and control system of CVC^2. Developing measures to assess a new C2 system is more complicated than developing measures for a weapons system, since a weapons system's measures can easily be quantified and a C2 system can not. This chapter also discusses the techniques that should be used in the evaluation CVC^2 with those selected MOEs, MOPs, and MOFEs.

The scope of tests and analysis designed to assess the potential contribution of an automated system, such as CVC^2, should include the administrative, logistical, intelligence, and operational aspects of those planning, execution, and reconstitution activities of at least a battalion task force and its subordinate elements during sustained operations.

Incorporating an automated command and control system into the command and control process offers many benefits to the units that possess and utilize that system. CVC^2 provides benefits at the various levels of command, phases of battle, and battlefield operating systems discussed in earlier chapters. Although each level and function may

benefit at each phase of the battle, Chapter VI discusses those functions and levels which benefit the greatest from the use of CVC^2. The three phases of battle (planning, execution, reconstitution) will be examined in regards to the seven battlefield operating systems (combat service support, command and control, mobility/survivability, manuever, air defense, intelligence, fire support) and the levels of command (vehicle/crew, platoon, company, battalion) within the battalion task force.

Chapter VII concludes the thesis with recommendations based upon the material presented throughout the paper. A synopsis of the accomplishments in the system's measurements is illustrated, in that the success of CVC^2 evaluated against the established measures is presented. The chapter highlights the advantages and disadvantages gained from an automated command and control system. It finishes with a discussion of CVC^2's ability to reduce the commander's C2 decision cycle time.

II. THE COMBAT VEHICLE COMMAND AND CONTROL SYSTEM

A. INTRODUCTION

In this chapter, CVC^2's capabilities, description, hardware components, and concepts are described as opposed to the functional aspects, which are discussed in Chapter VI. CVC^2 support of the commander and its relationship to IVIS (Intervehicle Information System) are also explained. This chapter covers CVC^2's mission, operation, description, and the communication network it creates. The system's operation section highlights the network's users inside and outside the battalion, the reports and graphical overlays it can transmit, and the support of the three phases of battle. The system description explains the CVC^2's relationship with IVIS, the major hardware components and their descriptions, and the interface nodes both within and outside the battalion.

B. CVC^2 MISSION

CVC^2's mission is to provide the maneuver force commander with accurate, timely information in order to make decisions, and assist him in preparing orders and supervising the order's execution. The system must be responsive to vehicle mission requirements and effectively facilitate continuous planning, coordination, and assessment in every situation. An additional mission of CVC^2 is to aid

vehicle commanders in identifying vehicles on the battlefield as friends or foes. By communicating and displaying friendly vehicle positions, CVC^2 will reduce the likelihood of incorrectly identifying a friendly vehicle as an enemy, thereby minimizing friendly-fire casualties. (SSCVCC 1992)

C. CVC^2 SYSTEM OPERATION

CVC^2 is an automated command and control (C2) system currently undergoing testing for installation into combat vehicles from the individual tank and infantry fighting vehicle through the task force command level. Nodes mounted within each vehicle enable the system "to talk to" other vehicles. Vehicles outside the CVC^2 system can communicate with CVC^2 equipped vehicles through interface nodes. (Refer to Figure 2-1.)

Figure 2-1 KEY:

BDE:	Brigade	CSS:	Combat Service Support
BN:	Battalion	CS:	Combat Support
CO:	Company	ALOC:	Administrative Logistics Center
PLT:	Platoon	TOC:	Tactical Operations Center

ATCCS: Army Tactical Command and Control System

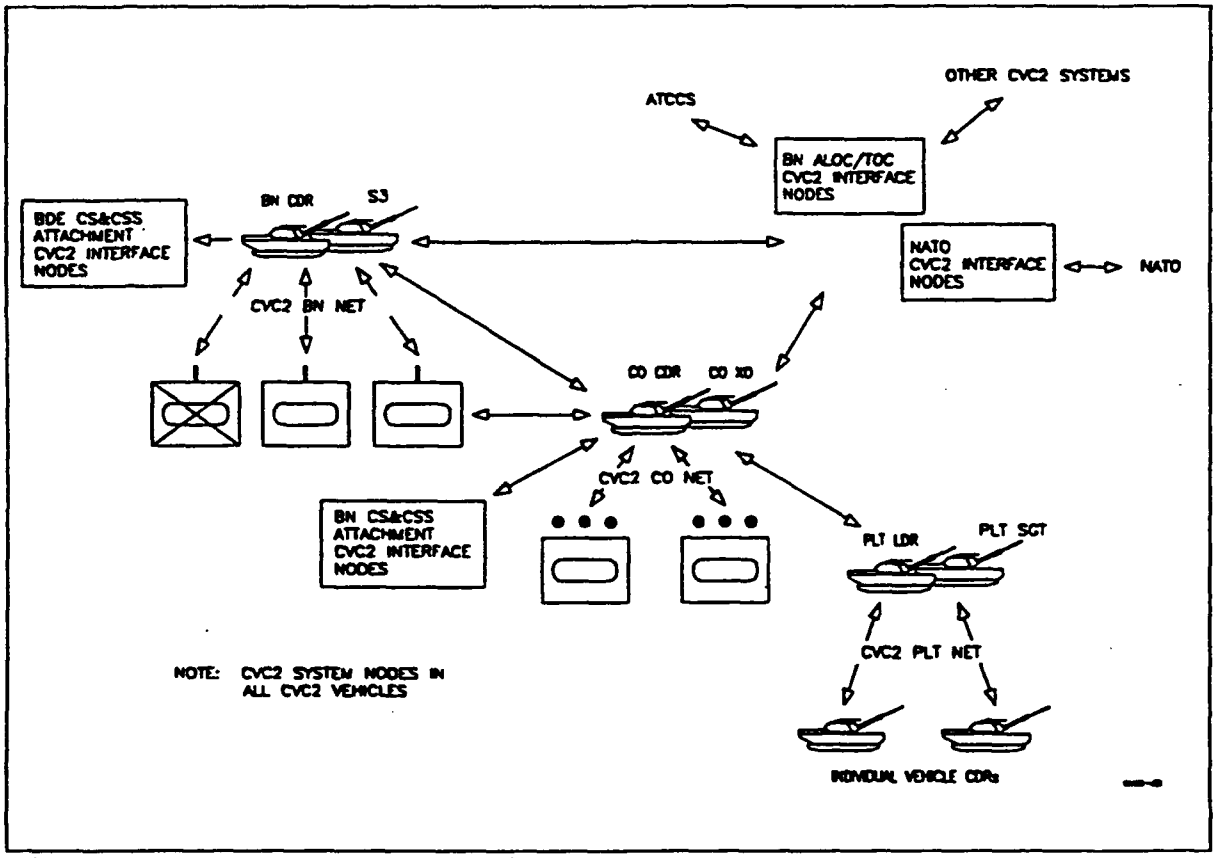

Figure 2-1: CVCC System Diagram (SSCVCC 1992)

This system prepares, collects, organizes, displays, and disseminates pertinent real-time battlefield information to assist commanders in C2 at the tactical levels of task force/battalion, team/company, and platoon. CVC^2 is an attempt to get the friendly commander inside the C2 decision cycle of the opposing enemy commander. This would permit U.S. forces to act more quickly than the enemy, thus gaining the advantage in time and space. CVC^2 provides the following C2 decision aids:

* near real-time information on enemy activity
* coordination of mission planning via overlays
* knowledge of friendly vehicle locations
* knowledge of threat locations to coordinate engagement activity
* coordination of team member movement (space and time) at all echelons up to battalion
* voice override with audible tone during digital data burst transmission (Diaz, 1992)

CVC^2 is designed to function between the individual combat vehicle and task force commander and tactical operations center, so that all CVC^2 equipped vehicles may access the CVC^2 database. CVC^2's mission is to provide the maneuver force commander with accurate, timely information in order to make decisions, and assist him in preparing orders and supervising the order's execution. At the various levels of operation (vehicle, platoon, company team, battalion task force), CVC^2 can support the three phases of battle:

<u>Prior to the battle (planning)</u>

*development of plans
*dissemination of orders
*dissemination of fire support control measures
*dissemination of maneuver graphics
*coordination between adjacent, lower, and higher units

During the battle (execution)

*calls for fire on enemy locations

*automatic, accurate position location and heading of friendly vehicles

*intelligence updates on enemy positions

Post battle (consolidation and reorganization)

*units' situation reports on enemy and friendly position and deployment, and vehicle, ammunition, and personnel status

*reconstitution to rearm and resupply

*new orders for the next mission (Diaz, 1992)

To achieve this support, CVC^2 displays and transmits the following reports and overlays via the Commander's Information Display (CID). The icons used for friendly and enemy symbols and graphics adheres to current Army doctrine. A further description of the CID and its capabilities are covered in a later section of this chapter.

ALERTS:	OPERATIONAL REPORTS:	OVERLAYS AND ORDERS:
MOPP status	Contact	Warning order
Air	Spot	Operations order
NBC	Situation	Fragmentary order
	Bridge	Operations overlay
	Minefield laying	Enemy overlay
	Obstacle	Obstacle overlay
	Route	Fire Support Plan
		Fire Plan

PERSONNEL/LOGISTICS REPORTS:
Personnel status
Ammunition status-precombat
Ammunition status-combat
POL status-precombat
POL status-combat
Vehicle status

NBC AND SHELL REPORTS:
NBC 1
NBC 3
NBC 4
NBC 5
Shell, bomb, mortar
Strikewarn

CALLS FOR:
Position location
Close air support

MISCELLANEOUS:
Indirect fire
WILCO
Request for report
(SSCVCC, 1992)

Table 1 and Table 2 show those CVC^2 equipped vehicles that may send and receive the seven categories of messages, reports, and overlays. The two tables detail who may control the various messages, who may update graphical icon posting (e.g. enemy locations, friendly operations), and who is responsible to monitor, correct, and finalize and approve text and graphical updates. In accordance with a particular unit's current procedures, the control of the communications net is executed by the each unit's established Net Control Station (NCS). CVC^2's ability to rapidly reach many stations with numerous reports and updates is evident through the tables. Messages shown can be quickly set up and down the chain of command, decreasing planning and reaction times. The best use for these messages as part of CVC^2 and its benefits are discussed in later chapters.

TABLE 1: CVC^2 MESSAGE AUTHORIZATIONS (SSCVCC, 1992)

CVC2 MESSAGE TYPE	CVC2 DUTY POSITIONS AUTHORIZED TO GENERATE MESSAGE
MOPP Status	CO CDR, PL
Air Alert	ALL
REDCON Alert Condition	BN CDR, CO CDR, PL
NBC Alert	ALL
Warning Order	BN CDR, CO CDR, PL
Operations Overlay	CO CDR, PL
FRAGO Order	BN CDR, CO CDR, PL
Enemy Overlay	NONE [TOC(S2) Only]
Enemy Overlay Update	BN S3, BN CDR
Obstacle Overlay	NONE [TOC(S3) Only]
Obstacle Overlay Update	BN CDR, CO CDR
Fire Support Overlay	BN CDR, CO CDR
Fire Support Overlay Update	BN CDR, CO CDR
Fire Plan	BN CDR, S3, CO CDR, PL, PSG, WM
Sector Identification	CO CDR, PL
Call for Indirect Fire	CO CDR, CO XO, PL, PSG, WM
Call for CAS	BN CDR, CO CDR
Contact Report	ALL
Engagement Update	BN S3, CO CDR, CO XO, PL, PSG, WM
Spot report	ALL
Situation Report	BN CDR, BN S3, CO CDR, PL, PSG, WM
Bridge Report	CO CDR, PL
Minefield Laying Report	BN S3, CO CDR, PL
Obstacle Report	BN CDR, BN S3, CO CDR, PL, PSG, WM
Route Report	CO CDR, CO XO, PL, PSG, WM
Personnel Status/Request	ALL
Ammo Status/Request	ALL
POL Status/Request	ALL
Vehicle Status	ALL
NBC 1 Report	ALL
NBC 3 Report	NONE [TOC(S3) Only]
NBC 4 Report	BN CDR, BN S3, CO CDR, CO XO, PL, PSG
NBC 5 Report	NONE [TOC(S3) Only]
Shell, Bomb, Mortar Report	ALL
Strikewarn	NONE [TOC(S3) Only]
Position Update	ALL
WILCO	ALL
Request (for Reports)	BN CDR, BN S3, CO CDR, CO XO, PL

TABLE 2: CVC^2 MESSAGE RECEIVERS (SSCVCC, 1992)

MESSAGE TYPE	CVC2 SYSTEM NODE RECEIVERS	AUTO/MAN REVIEW
MOPP Status	All	Manual
Air Alert	All	Auto
REDCON Alert Condition	All	Manual
NBC Alert	All	Auto
Warning Order	All except BN CDR	Manual
Operations Overlay	All	Manual
FRAGO Order	All except BN CDR	Manual
Enemy Overlay	All	Auto
Enemy Overlay Update	All	Auto
Obstacle Overlay	All	Auto
Obstacle Overlay Update	All	Auto
Fire Support Overlay	All except PSG and WM	Auto
Fire Support Overlay Update	All except PSG and WM	Auto
Fire Plan	BN CDR,CO CDR,CO XO,PL	Manual
Sector Identification	CO XO, PL, PSG, WM	Auto
Call for Indirect Fire	CO CDR, CO XO, PL	Auto
Call for CAS	BN CDR	Auto
Contact Report	All	Auto
Engagement Update	All	Auto
Spot report	All except WM	Manual
Situation Report	All except WM	Manual
Bridge Report	CO CDR, CO XO, PL, PSG	Manual
Minefield Laying Report	All except PSG and WM	Manual
Obstacle Report	All	Manual
Route Report	All except PSG and Wm	Manual
Personnel Status/Request	CO CDR, CO XO, PL, PSG	Manual
Ammo Status/Request	CO CDR, CO XO, PL, PSG	Manual
POL Status/Request	CO CDR, CO XO, PL, PSG	Manual
Vehicle Status	CO CDR, CO XO, PL, PSG	Manual
NBC 1 Report	All	Manual
NBC 3 Report	All	Auto
NBC 4 Report	CO CDR, CO XO, PL	Manual
NBC 5 Report	All	Auto
Shell, Bomb, Mortar Report	All	Manual
Strikewarn	All	Manual
Position Update	All	Auto
Will Comply	All	Manual
Request (for Reports)	All	Auto

D. CVC^2 SYSTEM DESCRIPTION

CVC^2 is the primary component of the vehicle upgrade called Intervehicle Information System (IVIS), which is designed to increase the overall effectiveness of individual armored vehicles. IVIS is a series of improvements to driver, gunner, and commander positions on the M1A2 Abrams main battle tank and the M2/M3 Bradley infantry fighting vehicle. Some of these many improvements include the driver's navigation display, gunner's control and information panel, global positioning sensor, mission computer, and CVC^2. CVC^2 provides the "brains" or C2 for these improvements. (Refer to Figure 2-2.)

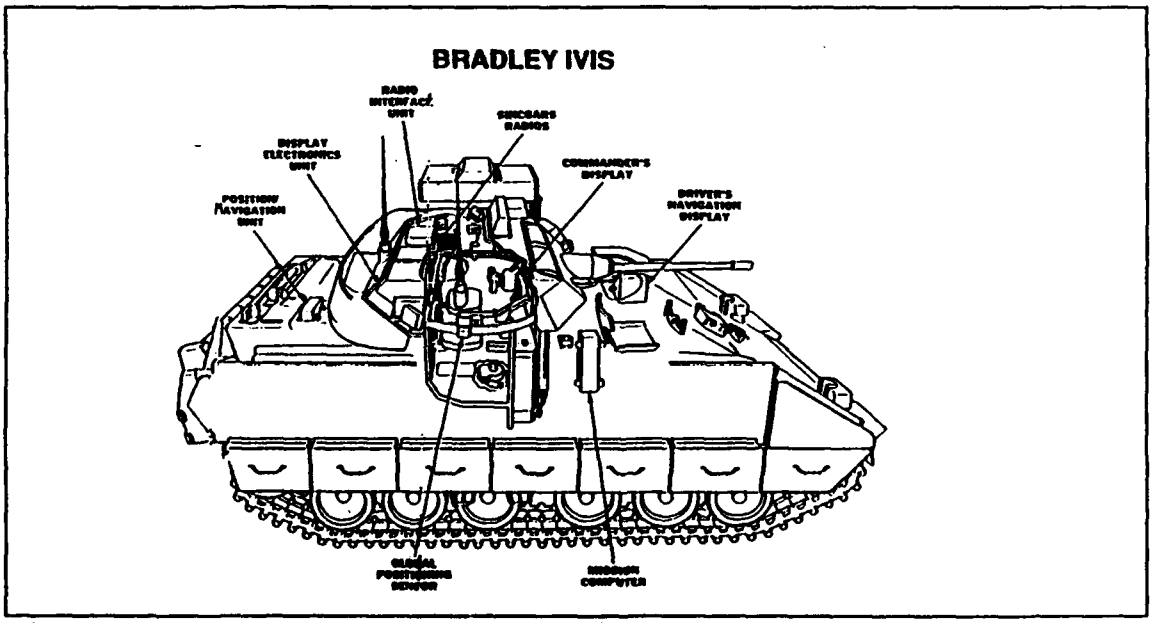

Figure 2-2: IVIS components (Diaz, 1992)

The CVC^2 system is comprised of replaceable vehicle-mounted nodes that aid in the performance of command, control, and communications functions for each vehicle. It provides user friendly graphical and message traffic displays on the Commander's Integrated Display (CID)(refer to Figure 2-3), a digital communications network over Single Channel Ground/Air radio (SINCGARS) to augment the existing analog communications network, a Radio Interface Unit (RIU) which interfaces between the CID and SINCGARS (refer to Figure 2-4), and network interfaces for the non-combat vehicles comprising the logistical communication nets within the task force and command and control linkage to the Maneuver Control System (MCS) at brigade headquarters and other units outside the task force not equipped with CVC^2.

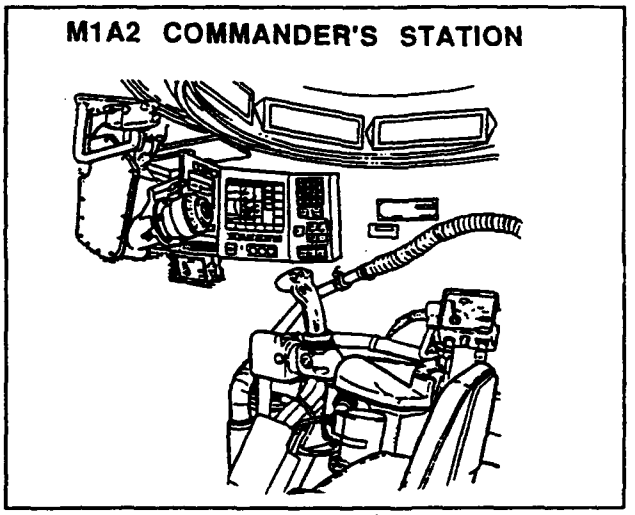

Figure 2-3: CID (Diaz, 1992)

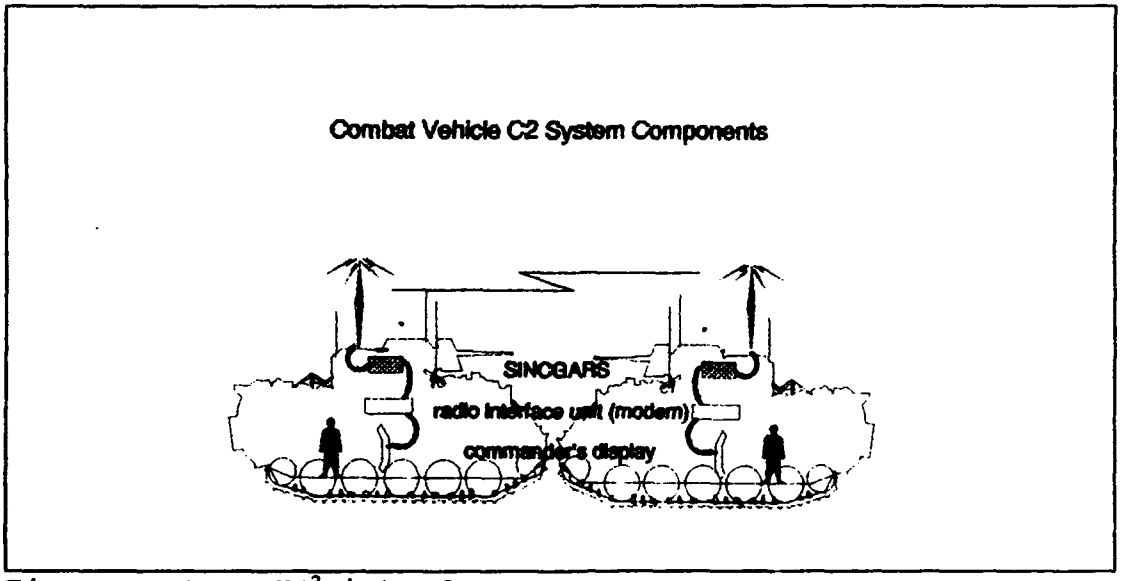

Figure 2-4: CVC^2 interface

1. Commander's Information Display (CID)

The CID is composed of Tactical Situation Displays (TSD) which are displayed on the interactive screen in the commander's position. The TSD presents the commander with a current and consistent picture of the battlefield situation. This picture consists of an electronic map, an own vehicle position/orientation indicator, and planning/situation overlays which utilize information contained in the CVC^2 system node's tactical/logistic information database. The TSD is projected on a computer-generated, color video display and is updated in real-time. Content and format of the display is tailored to the CVC^2 duty position of the user. How a commander interacts with CVC^2 and how it is used at each command level is discussed in Chapter VI.

Operation of each system's node is tailored to the echelon of operation of the vehicle commander. CVC^2 duty positions as defined for the CVC^2 nodes are:

*Battalion Commander
*Battalion S3
*Company Commander
*Company Executive Officer
*Platoon Leader
*Platoon Sergeant
*Wingman/Squad Leader

Each CVC^2 system node allows the user to identify their CVC^2 duty position and to tailor the operation of the node for the expected mission. This tailoring includes the following:

*Tactical situation display features and overlays
*CVC^2 message precedence levels and addresses
*Tactical symbol situation set (SSCVCC 1992)

The commander's information display presents received message status, position/orientation information, and map controls along the top; a tactical situation map comprising the electronic map and overlaid symbology in the middle; and function select buttons along the bottom. A touch overlay and a handgrip cursor control allow the operator to interact with the message queues, map controls, and function select menus. (Refer to Figure 2-5.) CVC^2 provides the capability to archive and retrieve information used to initialize the system configuration during periods of long-term inactivity and maintenance.

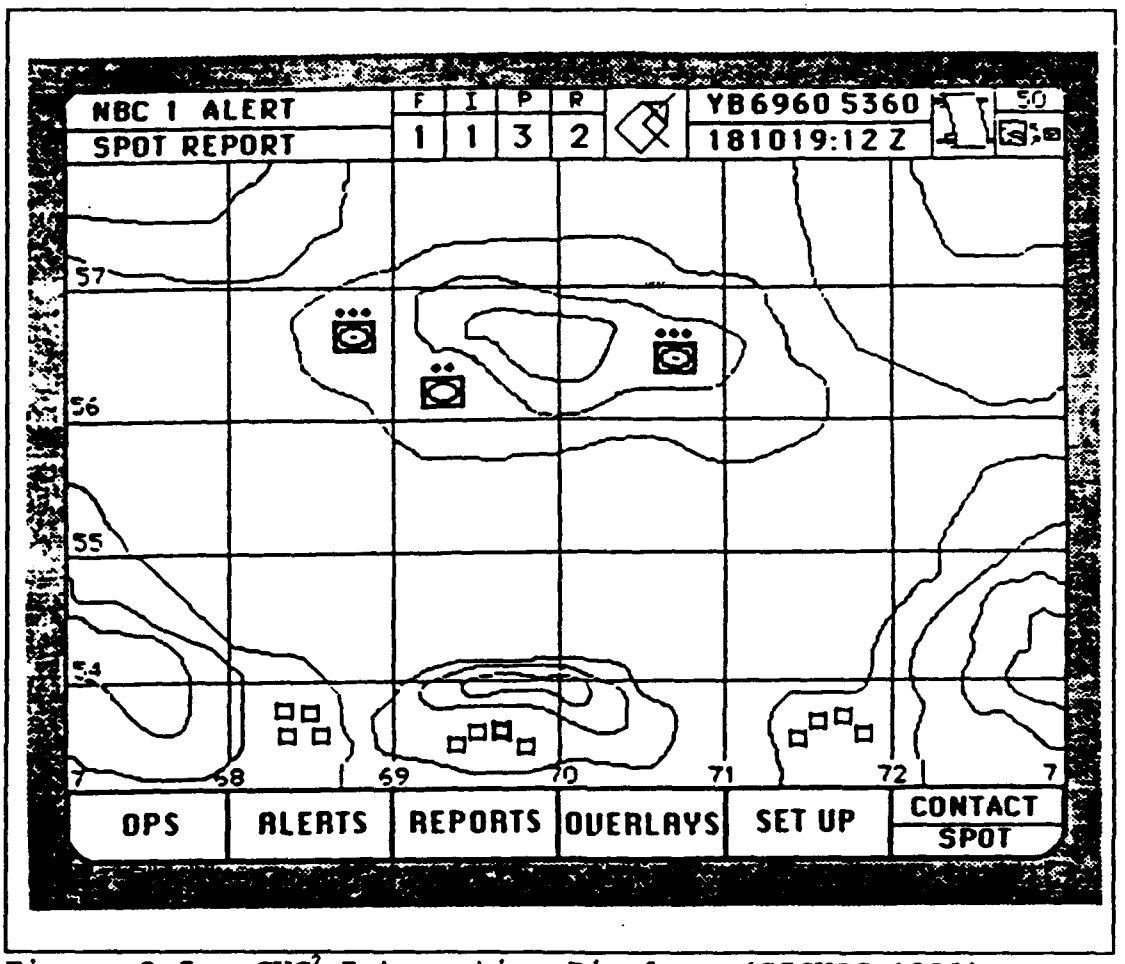

Figure 2-5: CVC^2 Interactive Display (SSCVCC 1992)

TSD generates the electronic map display using a color representation of Defense Mapping Agency topographic paper charts as a background image to overlay charts. The TSD provides user controls for setting the displayed map scale, map scrolling, and map interpretation functions. Each CVC^2 system node generates the electronic map display from digital map data stored on removable mass storage

media. The mass media storage cartridge contains the map data for the vehicle's area of operation.

The user has the ability to select four map scales: 1:25k, 1:50k, 1:100k, or 1:250k. TSD automatically scrolls the map to keep the user's moving vehicle at a fixed location in relation to the screen. A user can manually override the automatic scroll and move the center of the electronic map in any direction. An arrow is positioned on the side of the screen indicating the actual position of the vehicle in relation to the map orientation. TSD also provides the map interpretation features of distance and coordinates and elevation. When the user designates a path on the electronic map comprised of a series of points, the TSD calculates and displays the distance along that path. Additionally, the TSD displays the Military/Mercator Grid Reference System coordinates and elevation of points designated on the electronic map.

TSD provides the user the capability to selectively superimpose tactical planning and situation overlay graphics, generated from the overlay database, onto the electronic map.

Symbol design used on the graphical overlays adhere to current Army symbology as directed in FM 101-5-1. The symbology color code follows:

Friendly combat unit	Blue
Friendly fire support	Black

Friendly engineer item or obstacle	Green
Enemy items	Red
NBC contaminants	Yellow

TSD can display amplifying information from the tactical and logistical database on a selected symbol. This on-call information applies to friendly unit, obstacle, and enemy unit symbols. On a highlighted symbol, TSD can display the unit identifier, a color coded graphic illustrating the unit's status of ammunition, vehicle, personnel, and POL. Additionally, TSD can provide the ammunition, vehicle, personnel, and POL reports submitted by the selected unit. The following color coding portrays the unit's status:

90-100 percent	Green
80-89 percent	Amber
60-79 percent	Red
0-59 percent	Black

The selection of either the obstacle symbol or the enemy symbol will display the full text of the CVC^2 message which caused the inclusion of the respective symbol on the overlay.

The capability to store and transmit accurately portrayed graphics and full text messages permits the dissemination of orders over CVC^2. Figure 2-6 shows an example of a full text warning order matrix distributed over CVC^2 as displayed on the TSD screen. Figure 2-7, also

distributed over the CVC^2 TSD, shows an example of the necessary graphics that accompanies the warning order. Both are distributed to subordinate units to ensure correct preparation for and execution of the plan.

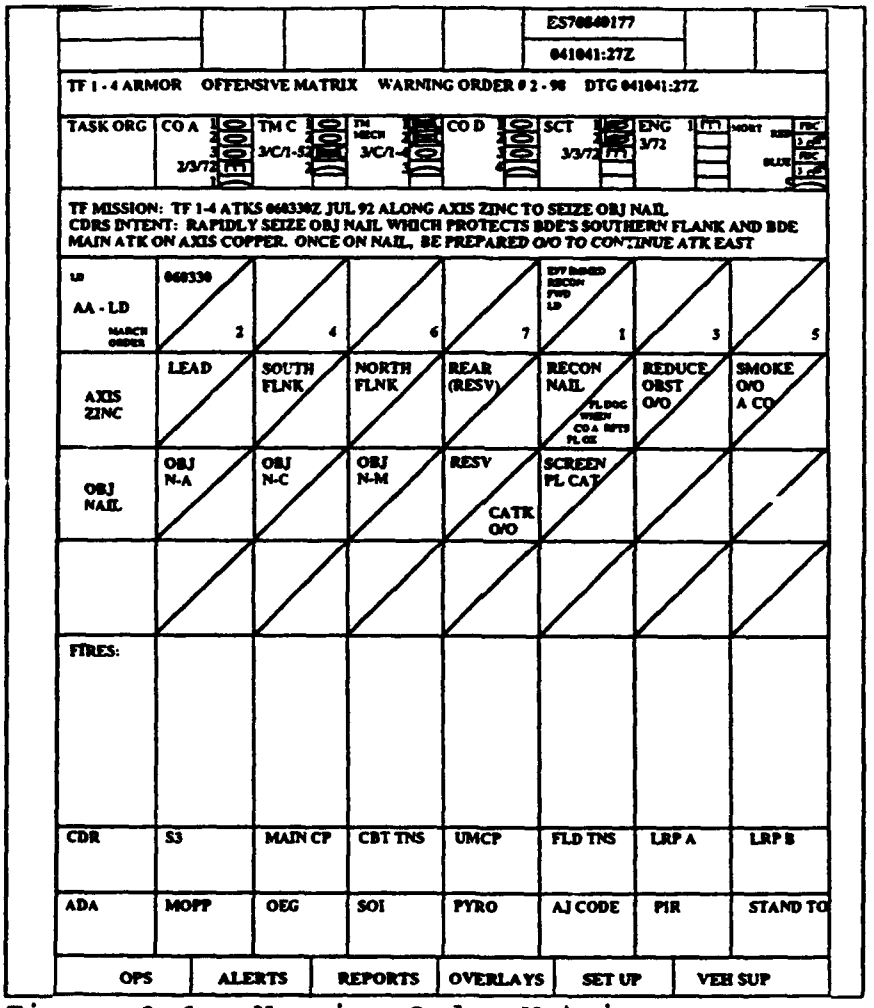

Figure 2-6: Warning Order Matrix (Bryla, 1992)

To read the warning order matrix Figure 2-6, first read horizontally and then vertically. A matrix provides an abbreviated method to issue orders without having to prepare and disseminate extensive written orders. Task Force (TF) 1-4 Armor distributed the offensive warning order # 2-98 matrix at 1041 hours on the 4th. Using Company A (column 2) as an example, under task organization, A company is composed of three armor platoons, one engineer platoon, and one air defense section. The task force mission is as stated. A Company is second in the march order from the assembly area behind the scout platoon (column 6). At 0330 hours on the 6th, A Company will cross the line of departure (LD) in the battalion lead to initiate the attack. Upon reaching objective, A Company will seize Objective N-A within the battalion's Objective Nail. Each of the other companies and platoons listed on the matrix are read in the same process. The remainder of the plan not filled out on the matrix will be disseminated with the operations order.

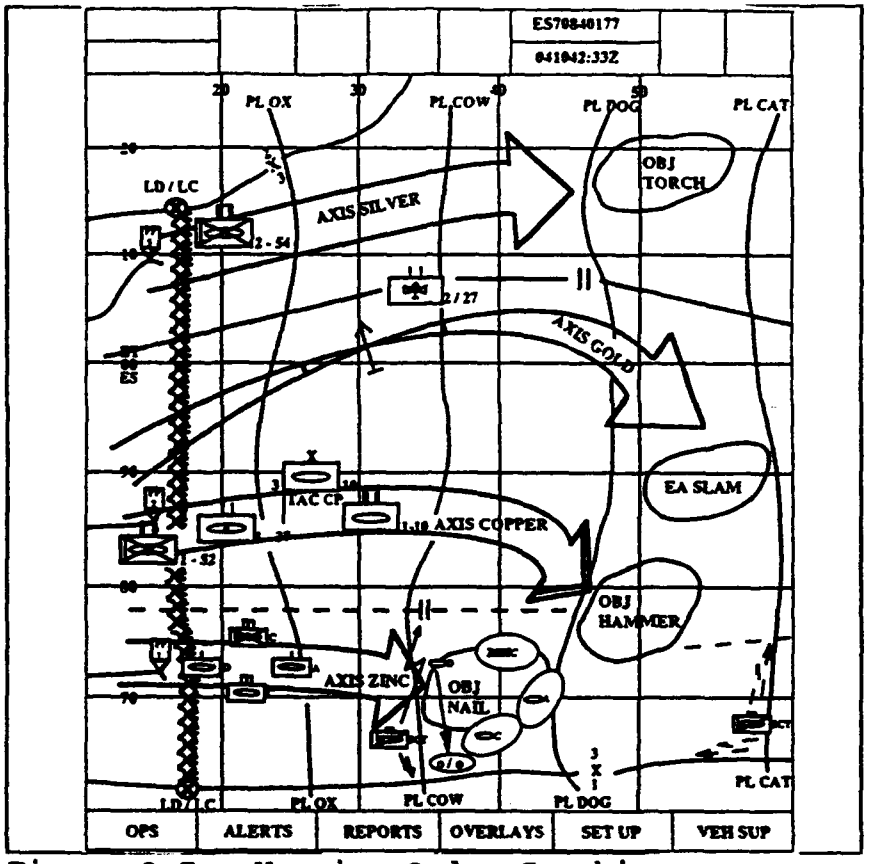

Figure 2-7: Warning Order Graphics
(Bryla, 1992)

Figure 2-7 portrays brigade level graphics that would accompany a brigade commander's order. Task Force 2-54 attacks Objective Torch in the north along Axis Silver. Aviation Battalion 2/27 attacks along Axis Gold and engages enemy in Engagement Area Slam. Task Force 1-10 executes the main attack along Axis Copper, followed by the 3rd Brigade commander in his tactical command post, and Task Force 1-52 in reserve.

2. SINCGARS

SINCGARS provides the advantage of the spread spectrum technique of frequency as a given measure of security because of the speed at which the radio transmits its digitized data and voice transmissions spread out over a number of frequencies. The radio transmitter (RT) changes frequencies 100 times per second. This starts from an initial frequency and pseudorandomly hops to another frequency within the bandwidth of the radio transmitter. These frequencies are preset and the net must be synchronized. The synchronization of the net can be done over the air with a net control station broadcast, or by a manual set for each radio.(SSED, 1989)

For increased security, the newer series SINCGARS RT-1523 has an internal encryption module. In the frequency hopping mode, an analog signal is processed within the RT. Upon initial transmission, the RT first transmits a series of synchronization patterns then converts the incoming analog signal to digital. After the external push to talk release, the RT adds an end of message (EOM). The receiving RT strips away the header and converts the digitized voice back to analog. SINCGARS is capable of storing eight single channel frequencies for push button automatic setting, and six frequency hopsets. It supports digital data communications with rates of 75, 150, 300, 600, 1200, 2400, 4800 and 16,000 bps. Vehicle mounted SINCGARS transmission

ranges are 35 km for analog voice and 29 km for digital data. (SSED 1989)

The CVC^2 will send its information to the SINCGARS via a radio integration unit or modem in the form of a digital or analog signal where it is multiplexed using frequency shift keying (FSK). The radio integration unit (RIU) is the key component that controls the input from the Commander's Information Display and buffers input to be broadcast. The RIU processes alphanumerics and graphics without impacting on voice traffic. It does bit error detection and correction for both transmission and reception of data. The RIU acts as an internal net control for communications by buffering data transfer while voice traffic has priority. Voice traffic can override a digital transmission. (Refer to Figure 2-8.)

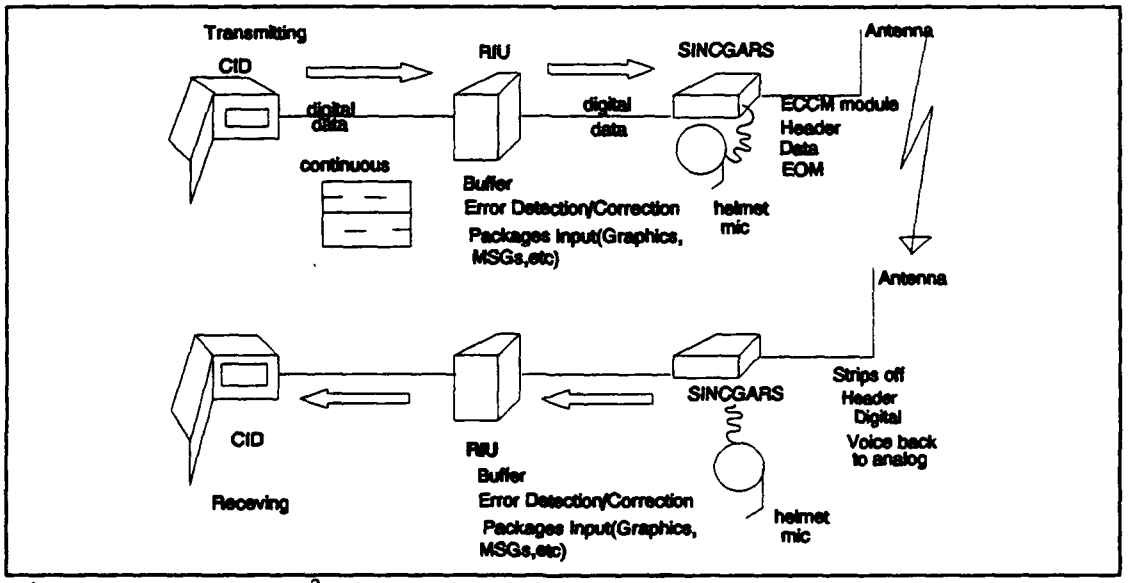

Figure 2-8: CVC^2 system components

CVC^2 interfaces with non-combat vehicles in the battalion task force to facilitate maneuver force command and control. The interaction between combat and non-combat vehicle CVC^2 nodes is executed through the use of interface nodes. As shown in Figure 2-9, the system interfaces with interface nodes at the Tactical Operation Center (TOC) and the Administration Logistics Center (ALOC). These interfaces connect the commanders to battalion intelligence, operations, personnel, and logistics staffs. They also provide the interface to the Maneuver Control System (MCS) and Army Tactical Command and Control System (ATCCS) at higher headquarters and NATO command and control networks. CVC^2 also provides interface with service support elements attached to combat units at the battalion and company level.

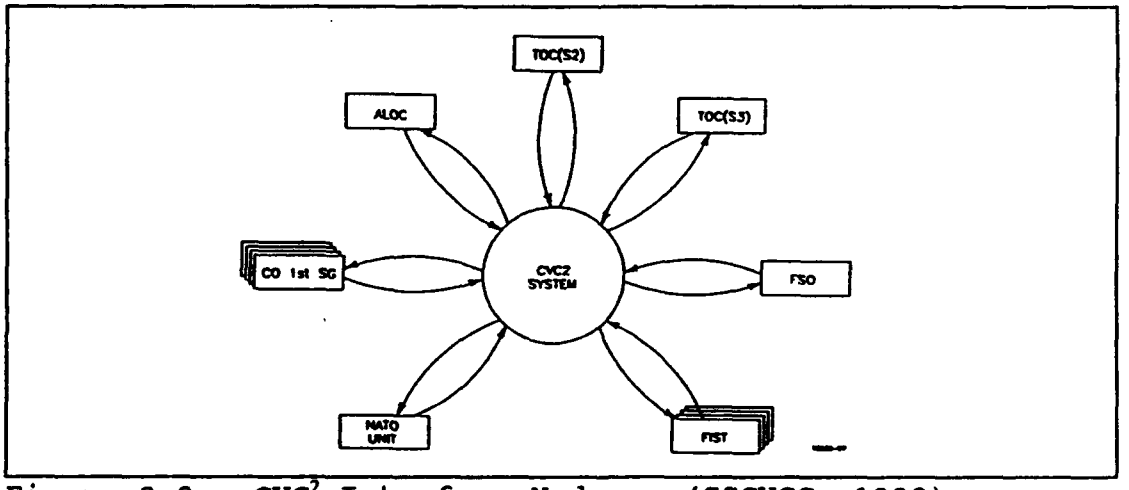

Figure 2-9: CVC^2 Interface Nodes (SSCVCC 1992)

E. COMMUNICATIONS NETWORKS

The CVC^2 system will operate on the voice combat radio networks established within a battalion with the primary networks being battalion, company, and platoon command. Digital communications will not interfere with analog transmissions since the system has voice override on digital messages and CVC^2 has a queuing capability. This queuing prevents messages from being lost and allows the message to wait for an opening on the radio transmitter. A CVC^2 node will be able to communicate with any other CVC^2 node operating on the same frequency.

In the normal mode of operation the CVC^2 node allows the user to generate digital messages containing overlay symbols and formatted text to other network CVC^2 nodes. The operator interfaces with a user-friendly menu-driven control/display panel, the CID. After the user selects the report he desires to send, the CVC^2 system prompts him for the required data elements to include and those nodes that will receive the message. A single node may be selected or all stations on the network can receive the message.

The combat radio net organization of a typical battalion is shown in Figure 2-10, while the CVC^2 battalion net is shown in Figure 2-11. CVC^2 not only provides more secure radio transmission because of frequency hopping and digitized message traffic, it reduces the number of radio nets necessary within the battalion.

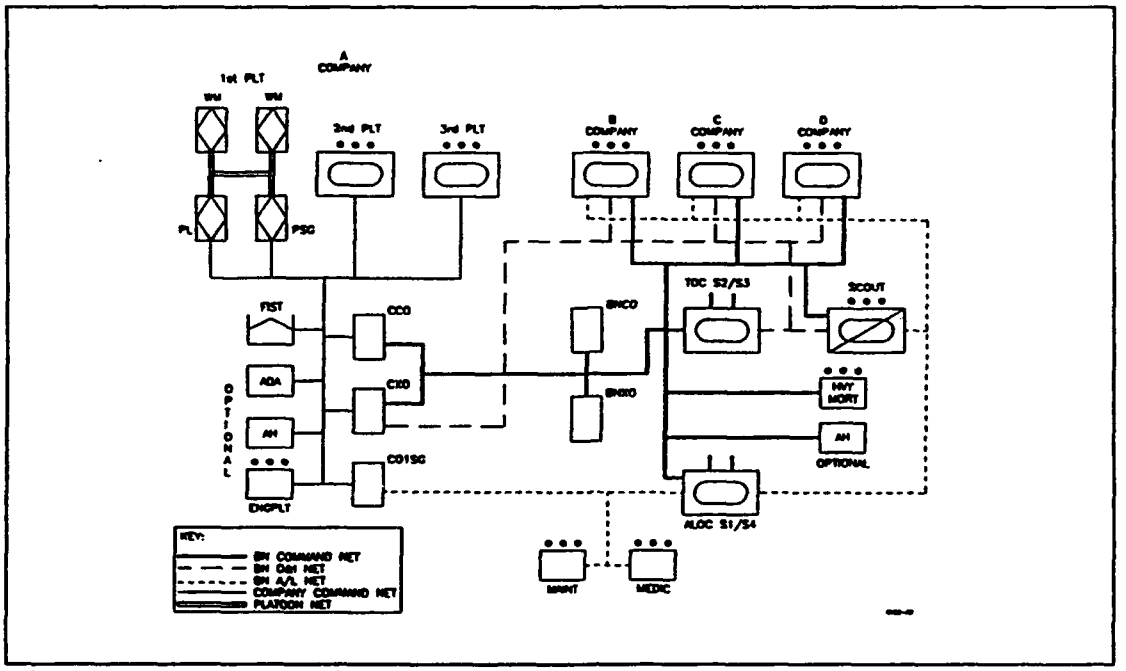

Figure 2-10: Typical Battalion radio network (SSCVCC 1992)

Figure 2-10 shows one battalion command, one operations and intelligence (O & I), one administrative/logistics (A/L), four company command, and twelve platoon command nets, while Figure 2-11 shows one battalion net, four company, and twelve platoon nets. CVC^2 offers the potential to consolidate networks and reduce a battalion's need for three different nets into one net. Command, O&I, and A/L may now be combined on a single frequency and not on three seperate ones.

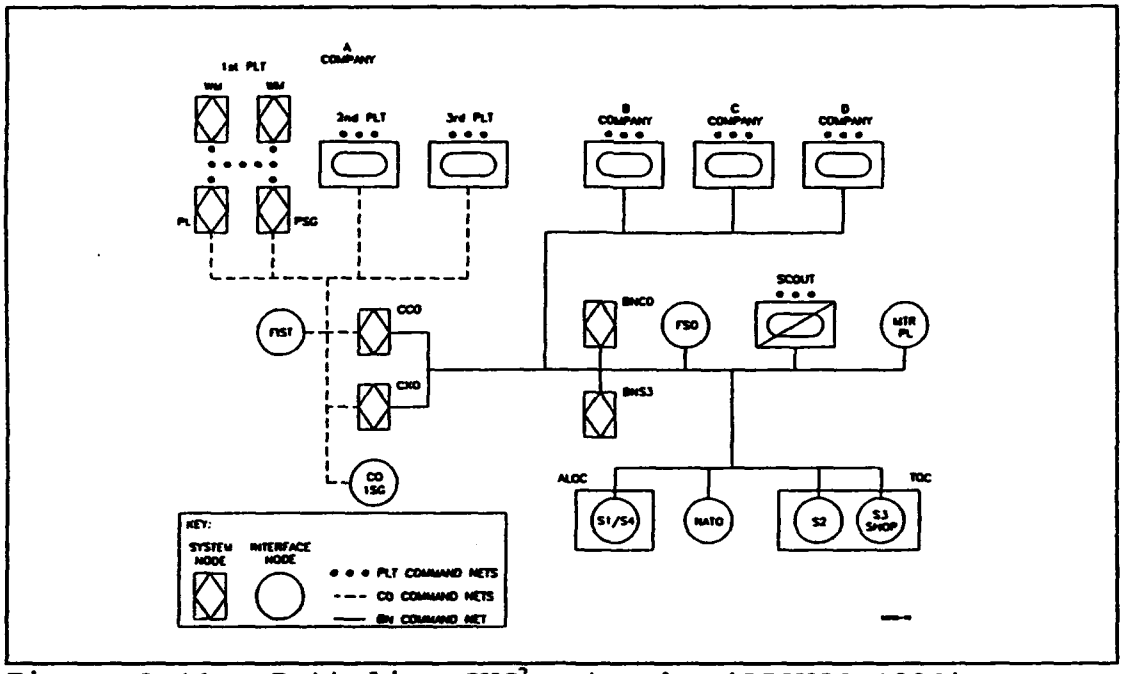

Figure 2-11: Battalion CVC^2 network (SSCVCC 1992)

F. SUMMARY

Throughout this chapter, CVC^2's missions, capabilities, operations, concepts, components, and relationship to IVIS were described. The C2 support that CVC^2 is able to provide the commander and the communications networks it can create was also discussed. This chapter examined the C2 system that will aid the commander, while in the following chapter the C2 process that supports the commander is described.

CVC^2 reduces the stress on a vehicle commander by automatically performing many of the management functions previously done manually. Information displays tailored to the user's needs minimizes the potential for information overload, permitting the commander to concentrate on

fighting the battle. CVC^2 does not replace the requirement for manpower, rather "it reduces the demand on the human mind and gives it time to do what it does best: creative decision-making". (SSCVCC 1992) Additionally, it reduces the commander's command and control participation to one net versus three. His ability to gather necessary information has been greatly enhanced.

III. COMMAND AND CONTROL AND ITS INFORMATION REQUIREMENTS

A. INTRODUCTION

The previous chapter demonstrated that the critical link between the elements of the command and control (C2 or C^2) system and the processes is communications. As communications serves only as the medium to exchange information within the C2 system, one must comprehend the inputs and outputs of that C2 system to understand the C2 process. In this chapter, the information requirements to support the command and control processes and systems available at battalion task force, company team, and platoon are discussed. The assets available at the three levels of command are identified and described. These inputs and outputs of the processes and systems are related to George E. Orr's Combat Operations Model (Orr, 1983) to provide a better understanding of how each piece fits into the C2 puzzle at battalion level. A clear understanding of the processes, systems, inputs, and outputs will aid in understanding the benefits of CVC^2 to the commander.

B. COMMAND AND CONTROL (C2)

It seems that whenever one reads a description of C2, it varies from one publication to another. Everyone appears to offer their own definition of C2.

The Department of Defense (DOD) defines command and control as:

> The exercise of authority and direction by a purposely designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission (Coakley, 1991).

However, the Joint Chiefs of Staff (JCS) has reduced DOD's definition and set forth the following definition of C2 for all services to follow.

> The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces to accomplish assigned missions (JCS Pub 1-02).

Although JCS Pub 1-02 does not explicitly define the concepts of command, control, or the C2 process, they are implicit and serve to establish a basis of C2 for this thesis. A C2 system consists of those facilities, equipment, communications, procedures, and personnel listed in the definitions. The JCS definition is intended to address a myriad of military activities. This section expounds on the definition as to how it impacts upon and affects a battalion task force and explains the components of the five highlighted subsystems of personnel, facilities, equipment, communications, and procedures, that a commander has at his disposal.

To further aid in comprehending the potentially abstract definitions of C2 as defined above, the terms command and control are elaborated upon. Command involves

receiving and assessing information about the environment which includes: enemy forces, friendly forces, intentions, positions, and capabilities, generating and selecting the best option, and sending out those orders to execute that option. Control describes the channels through which a commander's orders, advisories, admonitions, queries are passed to his forces.(Coakley, 1991)

Since the system under discussion is currently an Army program, the following descriptions on the Army's thoughts of command and control are offered. "Command is the authority that a commander in the military service lawfully exercises over subordinates by the virtue of rank or assignment." Command and control "is the process through which the activities of military forces are directed, coordinated, and controlled to accomplish the mission" (FM 101-5, 1984).

C. THE COMMAND AND CONTROL SYSTEM

As mentioned earlier, the system is composed of facilities, equipment, communications, procedures, and personnel. By Army doctrine, these components fall into three categories: C2 organization (personnel), C2 process (procedures), and C2 facilities (facilities, equipment, communications).(FM 101-5, 1984) Each category and component is discussed.

1. Personnel

Although the battalion commander is supported by his staff, he retains the primary responsibility for command and control within his unit. At battalion level, four staff officers in addition to the executive officer aid the commander. The four officers, S1, S2, S3, and S4, are briefly discussed.

The S1, battalion adjutant or personnel officer, has the responsibility for personnel and administrative functions. These duties include: unit strength accounting, personnel estimates, replacement assignment, casualty reporting, and awards and promotions. An additional duty that he assumes during combat is that of the assistant officer in charge of the ALOC (FM 101-5, 1984).

The S2, battalion intelligence officer, has the responsibility to collect and analyze information from internal and external sources and to transform that data into timely, pertinent, useful intelligence for the commander. In doing so, he develops the intelligence preparation of the battlefield overlays and intelligence estimate for planning purposes. In coordination with the S3, he prepares and tasks subordinate units with reconnaissance and surveillance plans of enemy activity (FM 101-5, 1984).

The S3, battalion operations officer, is the officer responsible for operations, plans, organization, and

training of the battalion's units. As the operations officer, his duties require close coordination with the other three staff officers. He is responsible for developing the battalion's combat operations orders to include coordinating all attached assets (fire support, electronic warfare, aviation, and engineers) with organic unit operations (FM 101-5, 1984).

The S4, battalion logistics or supply officer, is responsible for the logistical operations of supply, transportation, and maintenance. He ensures logistical support by planning, coordinating, and supervising all logistical resources, organic and non-organic. In a deployment, the S4 is the officer in charge of the ALOC (FM 101-5 1984).

Within their functional areas, these staff officers are required to continuously collect, collate, analyze, coordinate, and disseminate information to ensure efficient and successful operations. The officers must rapidly process this essential information to provide the commander with the accurate information necessary to make informed decisions.

2. Facilities

The command and control facilities employed by the commander are the means that allow for the processing and transmission of information and orders necessary to have effective command and control. The primary facilities that

exist within the battalion task force are the tactical operations center (TOC), the tactical command post (TAC), and the administrative/logistical center (ALOC) (FM 101-5, 1984). The ALOC is currently being renamed as the combat trains command post (CTCP). Although the names are used interchangeably, the functions remain identical for both.

The TOC, which is normally composed of the intelligence, operations, and fire support elements, is the headquarters responsible for monitoring the current engagements and for planning the next battle. At the TOC, located approximately 8-10 kilometers from the forward line of own troops (FLOT), the battalion executive officer (XO), the officer in charge of the center, integrates the logistical and operations aspects of the operation. The TAC is the battalion commander's mobile command post consisting of his vehicle and if he desires, the fire support officer's vehicle. It allows him to be in a position to see the battlefield at the critical time and place. The TAC's complement of personnel and its operating procedures vary within each organization. Battalion commanders may organize the TAC as they wish. The ALOC, located to the rear of the battalion operating area approximately 15-25 kilometers from the FLOT, provides the crucial administrative and logistics information and support. An additional vehicle not listed as a primary facility in the task force/battalion is the operations officer's (S3) vehicle. The S3 maneuvers his own

vehicle in accordance with the commander's orders so that he may serve as the commander's directed telescope. As the commander positions himself in the decisive place, he positions the S3 in the second most critical location. (Refer to Figure 3-1.)

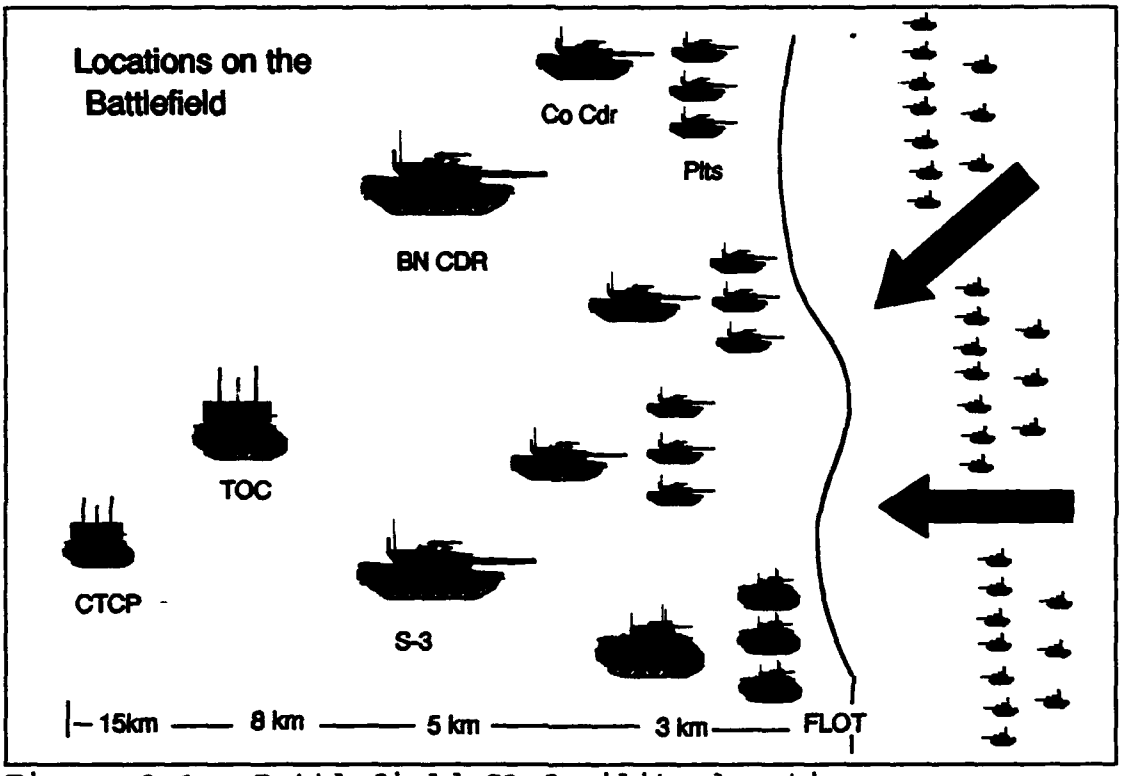

Figure 3-1: Battlefield C2 facility locations

3. Equipment

The equipment that the battalion commander has available to execute his command and control consists of the current family of analog and digital radios (e.g., AN/VRC series and SINCGARS), vehicles (e.g., M113 and M2 Bradley fighting vehicle and M1 Abrams tank), and limited isolated

computer support, which is not connected through a local area network (LAN). A new addition to the command and control equipment at battalion level is the mobile subscriber equipment (MSE). MSE provides an alternate means for the radios to pass information. Similar to a car phone, the commander can "dial up" a particular member of his staff and keep the FM frequencies clear. MSE also offers the capability to send paper copies of reports, orders, and graphics through a low quality fax machine to higher and adjacent headquarters and the ALOC. Currently, CVC^2 does not have an interface capability with MSE. MSE is designed to operate on single assigned frequencies like a cellular phone, while the SINCGARS radio of CVC^2 frequency hops on FM radio.

4. Communications

Within the battalion, there are three networks established for the commander to exercise command and control. They are the command net, intelligence net, and admin/log net. The command net is the primary command and control net and is used to exchange operational information, such as warning orders, fragmentary orders (frago's), spot reports, and situational reports. This net links the battalion commander to his subordinate commanders and the TOC. Other personnel may also speak on the command net as the situation requires. (Refer to Figure 3-2.)

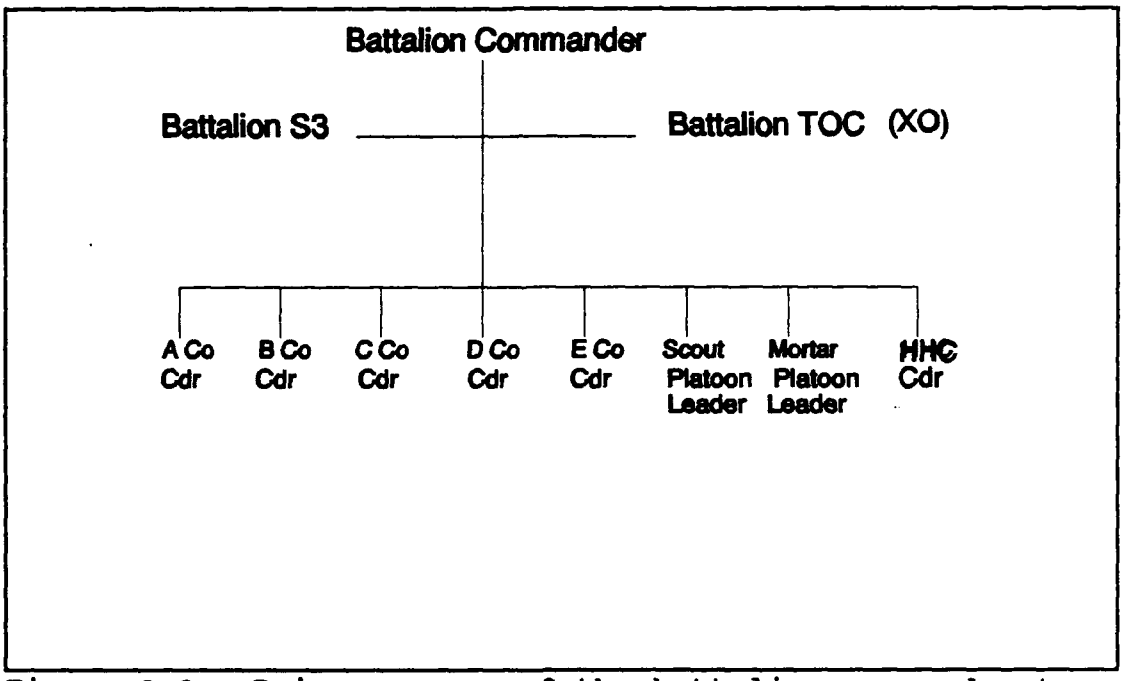

Figure 3-2: Primary users of the battalion command net

The second net is the intelligence net, referred as the operations and intelligence (O&I) net. This net provides a direct reporting link to the battalion intelligence officer (S2) from higher headquarters and organic and attached elements of the battalion. Within the battalion, the principal users of the O&I net are the reconnaissance units, the scout platoon (organic) and the ground surveillance radar sections (GSR, attached). Only intelligence traffic may be passed over this net, permitting the information to reach the staff planners with minimal delay. Reconnaissance units normally provide time critical information which can have a direct impact on the outcome of the current or future planned battle. (Refer to Figure 3-3.)

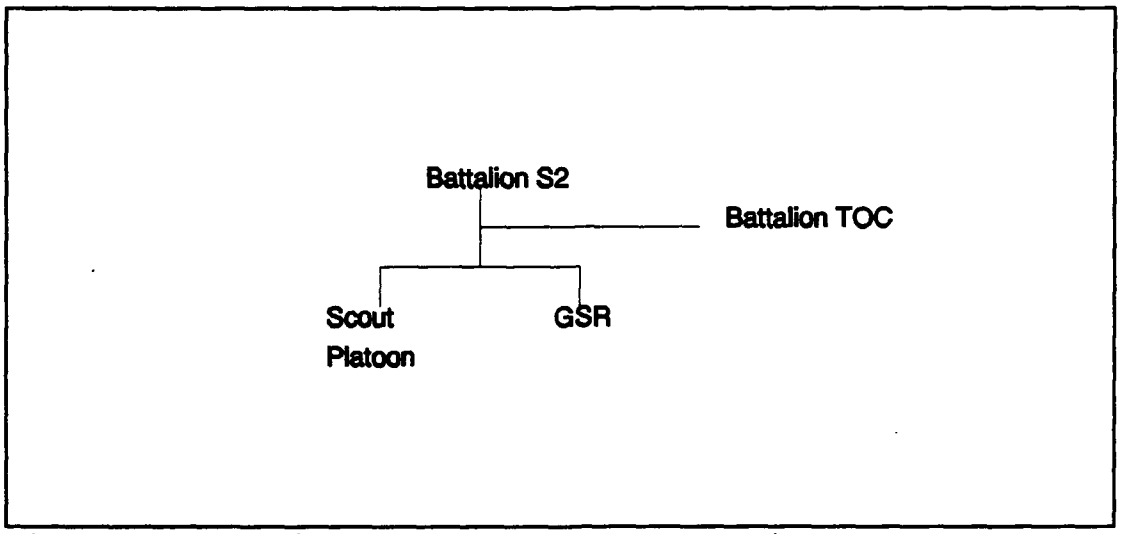

Figure 3-3: Primary users of the battalion O&I net

The third and final net within the battalion is the admin/log net. This net provides the essential administrative/logistic communications traffic. A sample of the traffic includes: casualty, fuel, food, ammunition, vehicle, and medical requests and status. (Refer to Figure 3-4.)

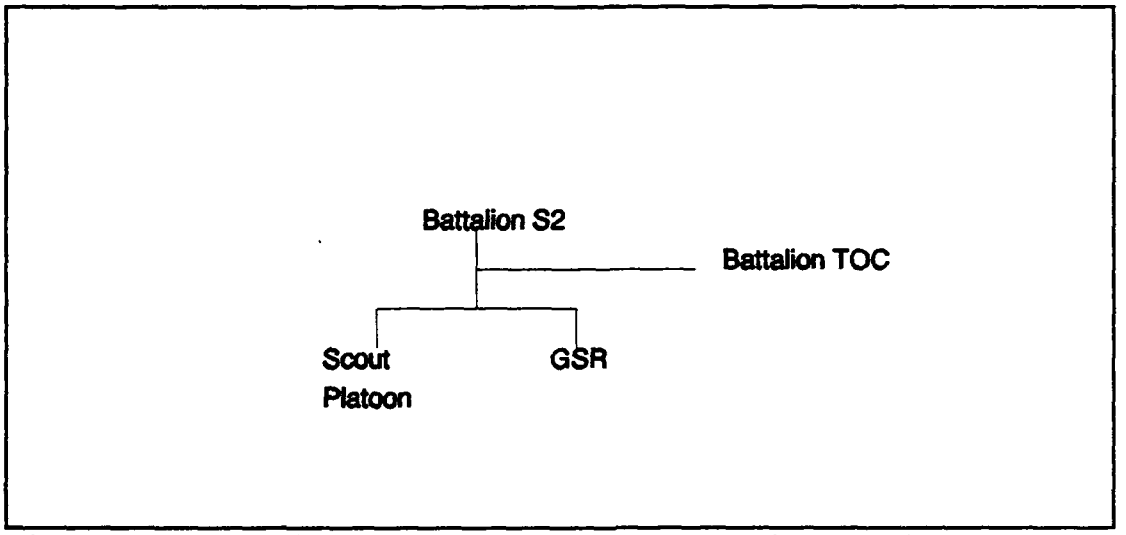

Figure 3-4: Primary users of the battalion admin/log net

The three battalion communications nets described earlier are all voice systems, with the exception of the MSE fax component. The current system provides extremely limited capability to send text or graphics over the MSE fax machine. The fax is slow, black and white, and of poor resolution. CVC^2 would greatly improve this part of the system with high quality, near real-time graphics and text. CVC^2 would also standardize the various battalion report formats. Currently, each unit establishes their own report formats and when one unit attaches to another, the attached subordinate unit must learn the new parent unit's report formats, often causing great confusion.

5. Procedures

As the reports are standardized within each particular battalion, so to are the procedures the commander uses to exercise his command and control. Although warfighting doctrine is outlined in Army doctrine and described in manuals, each commander may design his procedures to accomplish his mission as he desires. Each commander creates his own unit standard operating procedures (SOPs) that he wishes his soldiers to operate with.

The sections above described the personnel, facilities, equipment, communications, and procedures that are part of the C2 in support of the commander. Each element may vary slightly between different units as the

type of unit and personality of the commander dictate the specifics of each.

D. THE COMMAND AND CONTROL PROCESS

This section will relate George Orr's combat operations process model (refer to Figure 3-5) to the execution of command and control in battalion combat operations. The model attempts to represent combat operations at any level of military hierarchy. Orr's model is derived from earlier concepts developed by Joel Lawson and John Boyd (Orr, 1983).

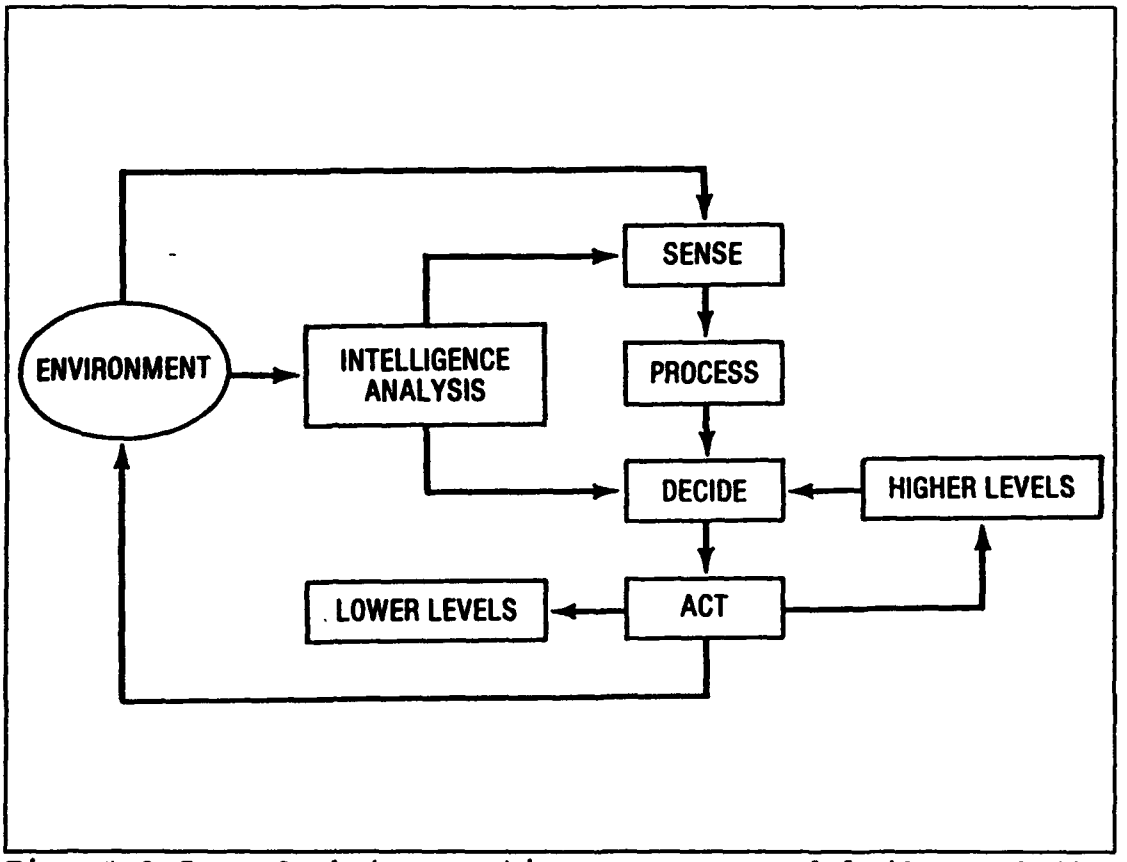

Figure 3-5: Combat operations process model (Orr, 1983)

Using a model provides a method for understanding what frequently appears to be chaos in combat operations. In regards to military operations, an often quoted German general from the Second World War once stated, "war is chaos and Americans practice chaos every day." The model permits the analysis of the command and control system within the battalion and offers some insight as to how the commander can effectively command and control his unit.

Orr's combat model is composed of the five basic functions: sense, process, decide, act, and intelligence analysis. These functions are discussed in the following paragraphs.

The sense function involves all the systems and procedures that gather data from the environment which include: the scout platoon, attached ground surveillance radars, field artillery forward observers, company reports, and higher headquarters intelligence updates. The goal is to provide continuous coverage of the environment under all conditions. This data is compiled so that the process function next occurs.

The process function involves all the processes and procedures used to deduce the occurrence of specific events or situations from the data gathered in the sense function from the environment. It includes guidance and additional information yielded by the intelligence/analysis function and is used to match patterns known to indicate specific

situations or events. Within this block, the results of the processing are displayed to the decision maker. Raw data from sensors, intelligence and analysis reports, and commander's guidance are transformed into spot, situation, and status reports, and course of action proposals required by the decide function.

The decide function is the primary function executed and has the most impact on a unit's operational effectiveness (Metersky, 1986). This function requires the commander to take into account the guidance from higher headquarters, the input from the intelligence/analysis function, and outcome from the process function. A commander must demonstrate problem solving skills, commonly referred to as decision making, and select a final course of action to issue to his unit.

The act function is the linkage between the commander's control of the situation and the environment. Act provides the means to execute desirable changes in the environment. A battalion commander has several parameters which impact upon his act function. These basic parameters are the unit's lethality, vulnerability, maneuverability, and response time. This function executes the outcome of the decide function.

In the intelligence/analysis function the two essential tasks of search and forecasting occur. Search entails the quest for information concerning the organization,

structure, capabilities, and intentions of the enemy. Gathered information ties together the meaning of previously observed activities and situations. The second task that occurs is that of forecasting changes to the current environment. These forecasts guide the sense function by indicating where and what to look for, guide the process function by identifying the patterns that signal specified events and situations, and guide the decide function by providing assessments and forecasts of the situation and the evaluation of friendly and enemy possible courses of action. Completeness, accuracy, and responsiveness are imperative to the intelligence/analysis function (Orr, 1983).

Orr's combat operations model offers a foundation upon which to build an understanding of the command and control functions and their interrelation. Since the model is drawn as a cyclic event, in some situations not all functions are completed. A process might be interrupted by new enemy activity or guidance from higher headquarters. Accuracy and timeliness of the information flow within the cycle are essential to successful execution.

E. RELATIONSHIP BETWEEN THE PROCESS AND THE SYSTEM

The previous sections described the system the commander has available for command and control and what command and control functions are involved. This section

describes how the battalion commander uses each of these elements of the C2 system in execution of the command and control process functions.

The battalion organization can be viewed as being organized into three major components: the commander and staff, the combat elements, and the combat support elements. Combat and combat support elements execute the act function. They provide the interface between the commander and the environment. The combat companies, scout platoon, and mortar platoon are the means used to influence changes in the environment. Their actions are in response to the commander's orders as part of the decide function. These actions can be as simple as remaining in position to executing a night combined arms attack. The combat support element's actions can range from providing the rations, fuel, ammunition, equipment, personnel, and repair or replacement of destroyed combat vehicles in support of the combat element.

At battalion level, the scout platoon and the ground surveillance radar sections primarily execute the sense function. Combat companies execute the sense function when in close proximity to the enemy. The scout platoon is considered the "eyes and ears" of the battalion. The platoon is used to collect information about the environment to feed into the intelligence/analysis and the process functions. Normally, information requirements focus on the

terrain in front of the battalion, the location and disposition of enemy units, and any enemy actions or movements.

The battalion commander and staff execute the intelligence/analysis, process, and decide functions. Although each are specialists in different areas, the sections' responsibilities overlap. These sections must operate in a coordinated and logical manner, sharing information in order to present the commander with complete and timely information.

The communications systems described earlier connect these sections. Figure 3-6 shows the battalion organization with the related process and how the networks connect them.

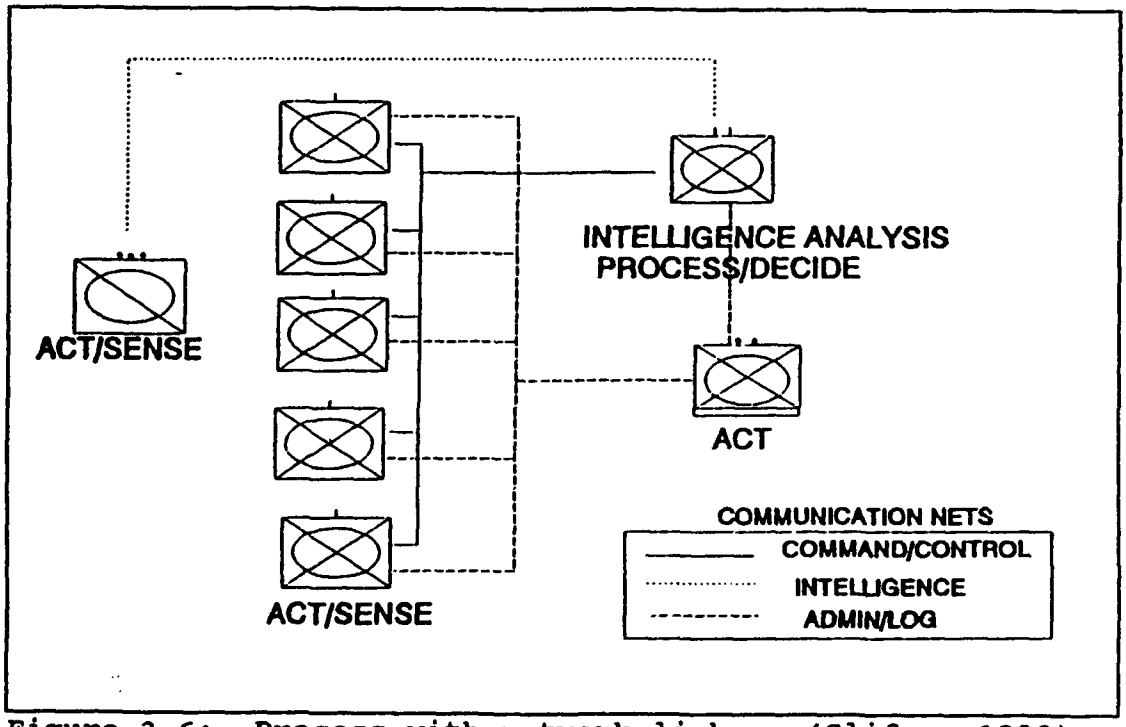

Figure 3-6: Process with network linkage (Slifer, 1992)

Many elements spread throughout the battlefield compose the system that a battalion commander has to execute command and control. Each element is responsible for at least one of the process functions. An effective communications network is critical in linking the separated elements because without good communications the C2 functions can not be connected. A failure to connect these functions will degrade the battalion's ability to accomplish successful combat operations.

F. INFORMATION REQUIREMENTS TO SUPPORT COMMAND AND CONTROL

The critical link between elements of the C2 system and process is communications. Communications networks are the primary means by which information and intelligence is exchanged within the system. In order to evaluate a C2 system, the inputs and outputs to the information requirements of the commander must be identified. This is critical for automation of a C2 system because a programmer can not write a program if he has no knowledge of the inputs that will be provided to his routine or of the nature of the desired output (Turban, 1990).

A useful starting point to determine the information a commander and staff need is to determine the factors considered when making tactical decisions. FM 100-5, the Army's Operations manual, identifies these factors as: mission, enemy, terrain, troops, and time available (METT-

T). The following offers a brief description of the various METT-T factors.

1. Mission

The mission is received from higher headquarters and states what each subordinate unit must accomplish. It clearly establishes the senior commander's intent and limitations. It is imperative that the mission be completely understood. The commander and S3 do the primary analysis of the mission. They decide the stated and implied tasks that the unit is instructed to accomplish (FM100-5, 1986).

2. Enemy

The S2 is required to present all available information to create an intelligence picture of the enemy. The exact information concerning the enemy is dependent upon the unit's mission. The commander, S3, and S2 examine these factors with regard to their impact upon friendly forces and their missions. This contributes to the decisions concerning future plans and operations the unit will conduct. Adequate information about the enemy permits the friendly unit to exploit enemy weakness, reduce friendly vulnerability, counter enemy strength, or capitalize on friendly strengths.

3. Terrain and weather

The S2 is also responsible for providing information on terrain and weather. He uses maps and

overlays to illustrate his terrain analysis. This analysis involves an examination of the effect of terrain upon enemy and friendly forces in the following areas: observation and fields of fire, cover and concealment, obstacles, key terrain, and avenues of approach.

a. Observation and fields of fire

Observation applies as to what can be seen, while fields of fire determines what can be hit by direct fire.

b. Cover and concealment

Cover protects personnel and equipment from indirect and direct fire. Concealment prevents observation of one force by another. However, concealment may or may not offer cover at the same time.

c. Obstacles

Natural or man-made obstacles that impede movement must be considered. The commander requires the location, extent, and strength of those obstacles to incorporate into his plan.

d. Key terrain

Key terrain is any area that provides a marked advantage to the force that seizes and controls it. An example of key terrain is a hill that permits one unit to observe or fire upon another.

e. Avenues of approach

Avenues of approach are the major routes that an enemy can approach into the battalion's area. These routes are evaluated for maneuverability, obstacles, and locations where an enemy or friendly force can be disrupted or ambushed.

f. Weather

Weather can affect men, equipment, and terrain because adverse weather can bring operations to a halt. The S2 provides the commander with information concerning temperature, precipitation expected, sunrise and sunset times, and moon phase with the resultant illumination percentage level.

4. Troops available

A commander must possess information about his own troops, such as: location and disposition, state of maintenance and supply, personnel status, morale, and state of training.

5. Time available

This is critical to every phase of an operation. All command and control systems must make efficient use of time. The Army uses the "one-third, two-thirds" rule in an effort to ensure efficient use of this critical issue. A higher headquarters should only use one-third of the available planning time. The two-thirds belongs to the subordinate unit for their planning purposes.

METT-T allows the grouping of relevant information for analysis in order to produce the best plan. This short description of the elements of METT-T illustrates the commander's and staff's required amount of information. The exact type and amount of information depends upon the mission that the unit has been tasked to accomplish. The amount of information actually available for use will depend on the resources available to gather the information, the amount of information already existing in some kind of database, and the time a commander and staff can wait for updated information.

G. METT-T AND ORR'S COMBAT OPERATION MODEL

Orr's model shows higher headquarters providing input into the decide function (Figure 3-5), often in the form of a mission. The commander and staff conduct METT-T analysis of the mission and determine information requirements. These requirements are then tasked to the companies and scout platoon to collect the desired information as part of the act and sense functions. The S2 may be tasked to provide weather and terrain analysis while the S4 is tasked to develop a logistics plan to support the operation as part of the intelligence/analysis and process functions. The required information comes into the S2 and S3 who evaluates it as part of the intelligence/analysis function, organize and insert it into the plan as part of the process function.

This process is reiterated until the plan must be disseminated or planning for the courses of action is complete. The commander then executes his responsibilities, the decide function, and selects a course of action for the plan.

H. INFORMATION INPUTS

Many sources can be asked to provide information to meet the requirements. Combat and combat support elements use a number of preestablished standard report formats to transmit the information within the C2 system. These standard reports fall into one of two categories, tactical or logistical. The reports provide different types of METT-T information depending on the type of report. A spot report, a tactical report, provides information as to the location of enemy vehicles. An ammunition report provides information as to the quantity status of ammunition that a friendly unit has on hand. The Army is currently trying to standardize the reports to increase interoperability between units.

I. INFORMATION OUTPUTS

The output of intelligence analysis, process, and decide functions are the plans and orders issued to lower echelons. These missions are issued in one of three formats: Warning, Operations, or Fragmentary Orders. Each

are standardized Army wide. They are transmitted to subordinate units either by voice, courier, or face to face meetings. Because of the complex nature and detail of the operations order it is frequently communicated by gathering the commanders and staff in one location to issue the order. Our present system does not have the capability to transmit overlays or text over radios. Both must be hand carried. This type of system has significant shortcomings in that commanders are pulled away from their units for long periods of time and are consolidated with the other leaders of the battalion in a single location in a hostile environment.

J. SUMMARY

In this chapter, the C2 processes and systems available to the battalion commander were examined. Understanding the inputs and outputs of the process will assist in the comprehension of CVC^2's benefit to the commander. Army doctrine uses METT-T analysis to sort information and to determine information requirements. Orr's Combat Operations Model furnished a technique to compare the processes and systems to the functions.

To gather and store information within the present system paper forms, journals, and maps with acetate overlays that are updated by hand, and the memory of staff personnel are required. (FM101-5, 1984) The entire information transmission process, the intelligence analysis function,

and the process function are all manual. The standardized reports for both the input and output of information of the current system can be made more efficient with automation. CVC^2 applies automation to the process of information transfer and storage. This system hopes to decrease the amount of time and effort necessary to present accurate information to battalion commanders so that the commander's decision cycle time can be reduced in order to gain an advantage over the enemy commander.

The command and control process "in essence, is the process of making, disseminating, and implementing informed command decisions in order to obtain optimum effectiveness of the nation's military forces in peace time, crisis, conflict, or war." (Van Creveld, 1985)

The most important aspect of the process is the decision output, whose product is the commander's decision, since the pivotal element of the C^2 process is the commander. The commander's goal is the reduction of uncertainty about the battlefield environment which aids him in making optimal decisions.

IV. SPECIFIC TASKS AND THEIR EVALUATION SCHEMES

A. INTRODUCTION

Examples of the specific tasks for armor and infantry battalion task forces, company teams, and platoons that must be examined and how they should be evaluated are discussed in this chapter. The U.S. Army currently uses a series of Mission Training Plans (MTPs) based upon its Army Test and Evaluation Plans (ARTEP) to develop and evaluate the training of its units from the individual soldier to the highest echelons. Selected individual and collective tasks are outlined for the various specific missions. Although MTPs are created for units larger than battalion task force, this discussion is limited to battalion task force and below. Since there are numerous tasks that must be evaluated and trained at these levels, only a few need be examined to gain an understanding of the MTPs.

Army leadership has devoted a significant amount of time and effort in consideration of the wartime performance measures, MTPs, for its units. These MTPs serve as the baseline for the development of measures to evaluate new systems that increase the effectiveness of a unit. With the testing of the new command and control system, CVC^2, measures must be created to determine its effectiveness and potential for production and introduction into the Army's C2 system. Before creating new measures for CVC^2 evaluation,

one must discern those measures already in use. MTPs that serve as an evaluation tool for unit training and performance, also serve as the starting point for CVC^2's evaluation. This chapter will give the reader an understanding of those MTPs before developing the actual measures of CVC^2's evaluation in a later chapter.

B. MISSION TRAINING PLANS

Mission Training Plans (MTP) provide commanders and staffs a training and evaluation program for the tank battalion, infantry battalion, the battalion task force which is combined tank and infantry companies (ARTEP 71-2 MTP), the infantry company, the tank company, the company team which is combined tank and infantry platoons (ARTEP 71-1 MTP), the tank platoon and crew, and the infantry platoon and squad (ARTEP 7-8 MTP). MTPs are also developed for other types of platoons which are not discussed here. The MTP contains guidance for planning and executing training on critical tasks to wartime standards. As described previously, these MTPs build upon the subordinate unit's MTPs. (Refer to Figure 4-1.) It provides the link between the "how to train" doctrine and the "how to fight" doctrine.

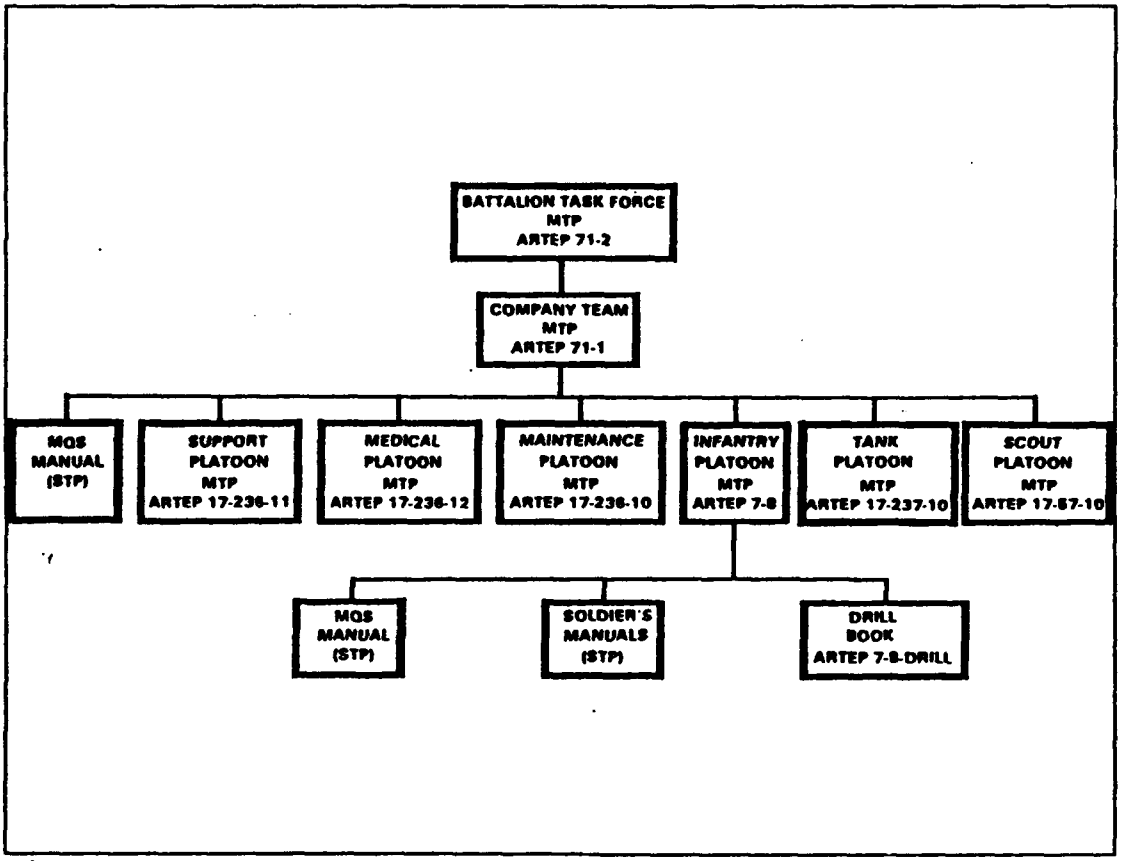

Figure 4-1: MTP echelon relationship (ARTEP 71-2 MTP, 1988)

The battalion task force has five critical, complex wartime operations, while the company team and platoon share the same seven critical tasks. Each task is composed of numerous subtasks that the battalion task force, company team, and platoon must execute to successfully accomplish their operations. The task force's five tasks/missions include:

* Offensive Operations
* Defensive Operations
* Retrograde Operations
* Reconnaissance and Security Operations
* Movement to Contact (71-2 MTP, 1988)

The company team and platoon's seven wartime critical tasks/missions are:

* Movement to contact
* Attack
* Raid
* Ambush
* Reconnaissance and security
* Defend
* Retrograde (71-1 MTP, 1988)

Refer to Matrix 4-1, 4-2, and 4-3 on the following pages for examples of the mission to task relationships of a battalion task force, a company team, and a platoon respectively.

	Offensive	Defensive	Retrograde	Recon and Security	Movement to Contact
MANEUVER TASKS (Continued)					
Reorganize 7-1-3022	X	X	X	X	X
Consolidate 7-1-3023	X	X	X	X	X
Perform Air Assault 7-1-3024	X				X
Breakout From Encirclement 7-1-3025	X		X	X	
Perform Screen 7-1-3026	X	X	X	X	
Breach Defended Obstacles 7-1-3027	X		X		X
Maintain Operations Security 7-1-3028	X	X	X	X	X
COMMAND AND CONTROL					
Command and Control the Battalion Task Force 7-1-3901	X	X	X	X	X
Perform S3 Operations 7-1-3902	X	X	X	X	X
Command Group Operations 7-1-3903	X	X	X	X	X
Operate Main Command Post 7-1-3904	X	X	X	X	X
Move a Command Post 7-1-3035	X	X	X	X	X
Establish a Command Post 7-1-3036	X	X	X	X	X
Maintain Communications 7-1-3401	X	X	X	X	X
INTELLIGENCE					
Perform Intelligence Operations 7-1-3905	X	X	X	X	X
Perform S2 Operations 7-1-3906	X	X	X	X	X
FIRE SUPPORT					
Employ Fire Support 7-1-3907	X	X	X	X	X

Matrix 4-1: Battalion task force mission to task matrix (ARTEP 71-2 MTP, 1988)

COLLECTIVE TASKS	MOVEMENT TO CONTACT	ATTACK	RAID	AMBUSH	RECONNAISSANCE AND SECURITY	DEFEND	RETROGRADE
INTELLIGENCE							
Maintain Operation Security	X	X	X	X	X	X	X
COMBAT SERVICE SUPPORT							
Perform Logistical Planning	X	X	X	X	X	X	X
Perform Tailgate Resupply	X	X	X	X	X	X	X
Perform Service-Station Resupply	X	X	X	X	X	X	X
Consolidate on the Objective		X	X	X	X		
Reorganize on the Objective		X	X	X	X		
Integrate Replacements	X	X	X	X	X	X	X
Provide Medical Evacuation and Treatment of Casualties	X	X	X	X	X	X	X
Provide Maintenance Support	X	X	X	X	X	X	X
Process Enemy Prisoners of War (EPWs)	X	X	X	X	X	X	X
COMMAND AND CONTROL							
Prepare for Combat	X	X	X	X		X	X

Matrix 4-2: Company team mission to task matrix (ARTEP 71-1 MTP, 1988)

COLLECTIVE TASKS	MOVEMENT TO CONTACT	ATTACK	RAID	AMBUSH	RECON/SECURITY	DEFEND	RETROGRADE	BATTLEFIELD OPERATING SYSTEMS
Construct Obstacles 7-3-1068						X	X	Mobility and Survivability
Cross Water Obstacle 7-3/4-1034	X		X	X		X	X	
Maintain Operation Security 7-3/4-1057	X	X	X	X		X	X	
Defend Against AirAttack 7-3/4-1027	X	X	X	X		X	X	Air Defense
Perform Aerial Resupply 7-3/4-1048	X	X	X	X	X	X	X	Combat Service Support
Perform Vehicle Operations 7-3/4-1062	X	X		X	X	X	X	
Sustain 7-3/4-1058	X	X	X	X	X	X	X	
Prepare for Combat 7-3/4-1046	X	X	X	X	X	X	X	Command and Control
Consolidate and Reorganize 7-3/4-1047	X	X	X	X	X	X	X	

Matrix 4-3: Platoon mission to task matrix (ARTEP 7-8 MTP, 1988)

The company team and platoon's seven tasks build directly upon and support the battalion task force's five tasks as seen in the mapping below.

Battalion Task Force	Company Team	Platoon
Move't to contact	Move't to contact	Move't to contact
Offensive Operations	Attack	Attack
	Raid	Raid
	Ambush	Ambush
Defensive Operations	Defensive Ops	Defensive Ops
Retrograde	Retrograde	Retrograde
Recon and security	Recon and security	Recon and security

C. TRAINING AND EVALUATION TECHNIQUES

Tasks are trained through the following techniques. Evaluation is conducted by the next higher commander from the unit executing the training.

* Individual soldier's manuals and leader training

- Officer/noncommissioned officer development (OPD/NCOPD): individual classroom style training for leaders down to squad and crew level.

- Chalk-talk: the commander or leader walks through a task or operation step by step with subordinate leaders and staff.

- Map Exercise (MAPEX): a low cost exercise for the commander or leader to train his subordinates and staff

in planning, coordinating, and executing operations and tasks on map boards and sand tables.

* Tactical exercises without troops (TEWTS): a low cost exercise conducted in the field on actual terrain with leaders and staffs but without troops; similar to a MAPEX.

* Battle Simulations: computer assisted exercises for the battalion staff and leaders include:

- ARTBASS: company level computer simulation
- JANUS: platoon/company level computer simulation
- SIMNET: a platoon level trainer at Fort Knox, KY

* Collective training and evaluation exercises for battalion through squad and crew level:

- Command Post Exercise (CPX): a medium cost exercise that may be conducted in garrison or in the field to exercise the battalion staff and commanders to lead and control tactical operations by use of tactical communications.

- Command Field Exercise (CFX): the leadership of the battalion down to company or platoon level goes to the field to conduct tactical operations without full troop strength.

- Field Training Exercise (FTX): the entire battalion goes to the field for one week or longer duration and conducts tactical missions. May be composed of several combined STXs.

- Situational Training Exercise (STX): a short term FTX with limited missions that emphasizes a short closely related group of tasks.

- Combat Training Center (CTC): the entire battalion rotates through an Army operated training center offering the unit as close to realistic combat conditions short of actual war. (71-2, 1988)

As shown in Figure 4-2, the lower the level of the training and evaluation technique, the lower the level of realism. The method may be simple to execute and replicate, but the realistic influences of combat are absent. The ultimate objective is to train as the unit would fight in combat regardless of the technique and level executed.

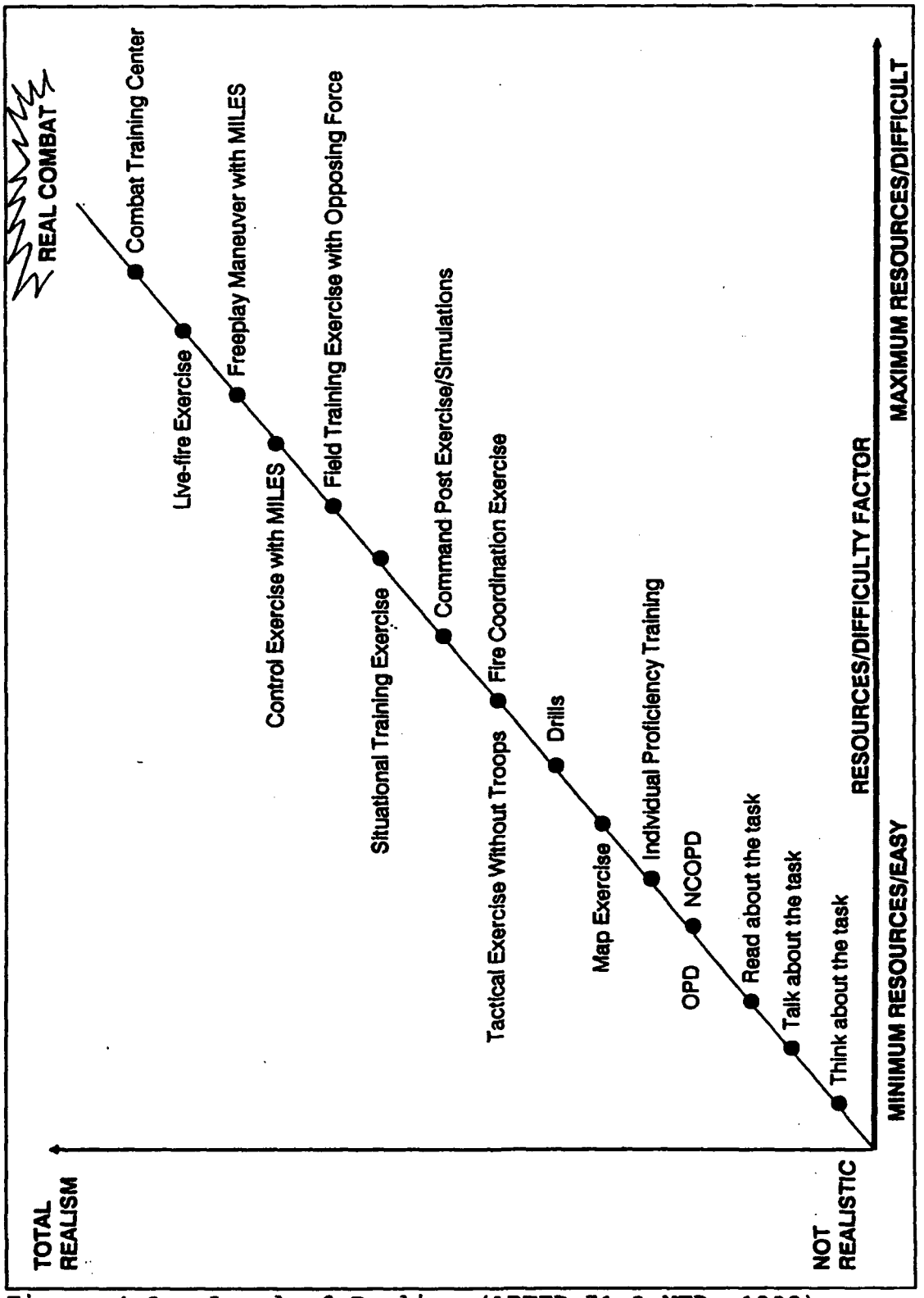

Figure 4-2: Level of Realism (ARTEP 71-2 MTP, 1988)

D. COLLECTIVE TASKS

To accomplish a battalion task force operation, the execution of a sequence of specific collective tasks with start and end points is involved. Figure 4-3 provides a block diagram of the possible tasks that may be combined into a company team attack operation. Figure 4-4 provides a block diagram of the possible tasks that may be combined into a platoon attack operation as part of its higher company team's operation. For example, an attack mission could consist of the following specific tasks/missions:

* Occupy an assembly area
* Perform a tactical roadmarch
* Perform a passage of lines
* Move tactically
* Assault
* Consolidate and reorganize

A unit may not necessarily have to accomplish all the tasks outlined in Figures 4-3 and 4-4 on each and every operation. Although the mission may be attack for both the company team and the platoon, each may have different subtasks to accomplish.

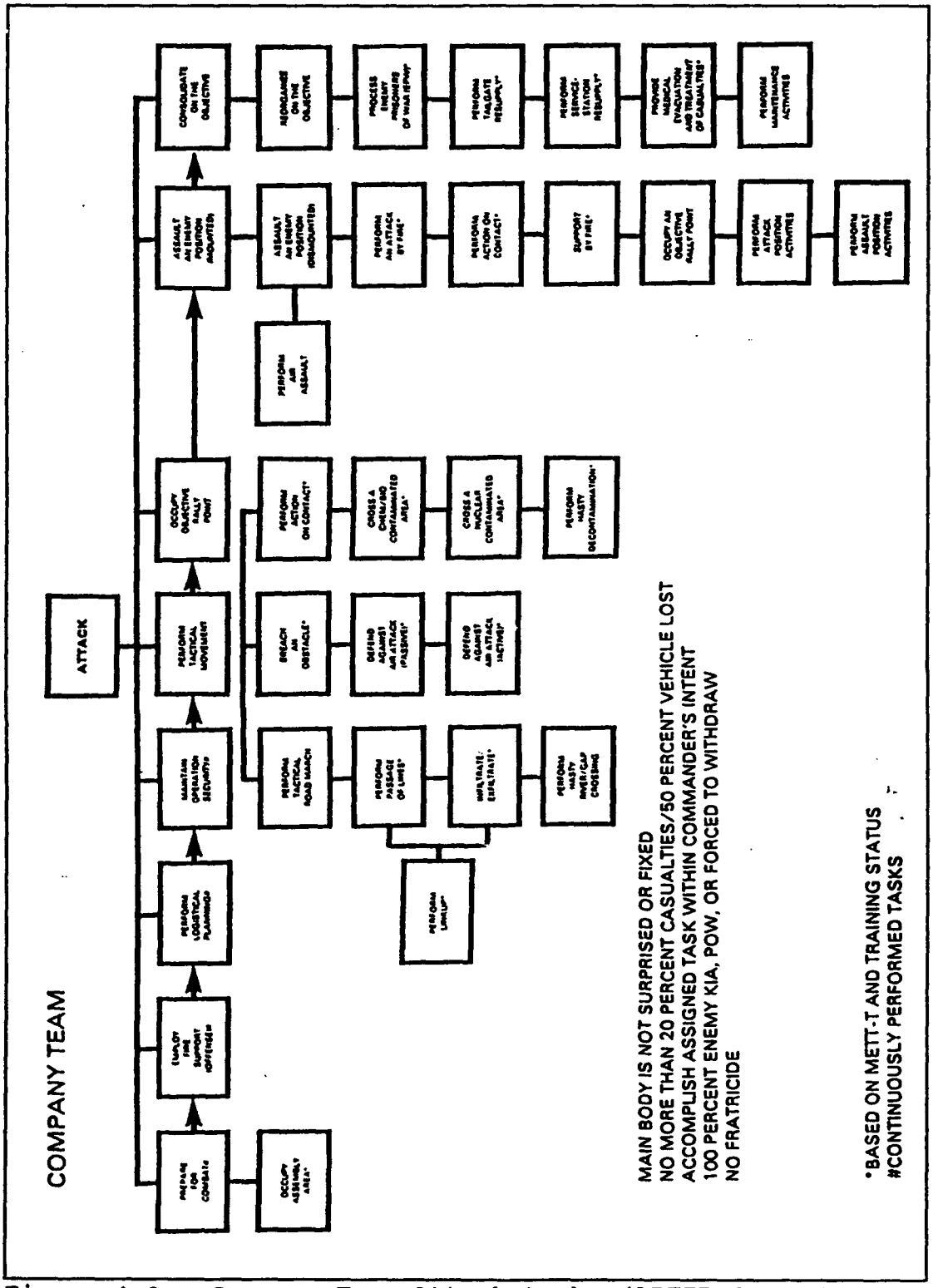

Figure 4-3: Company Team Attack tasks (ARTEP 71-1 MTP, 1988)

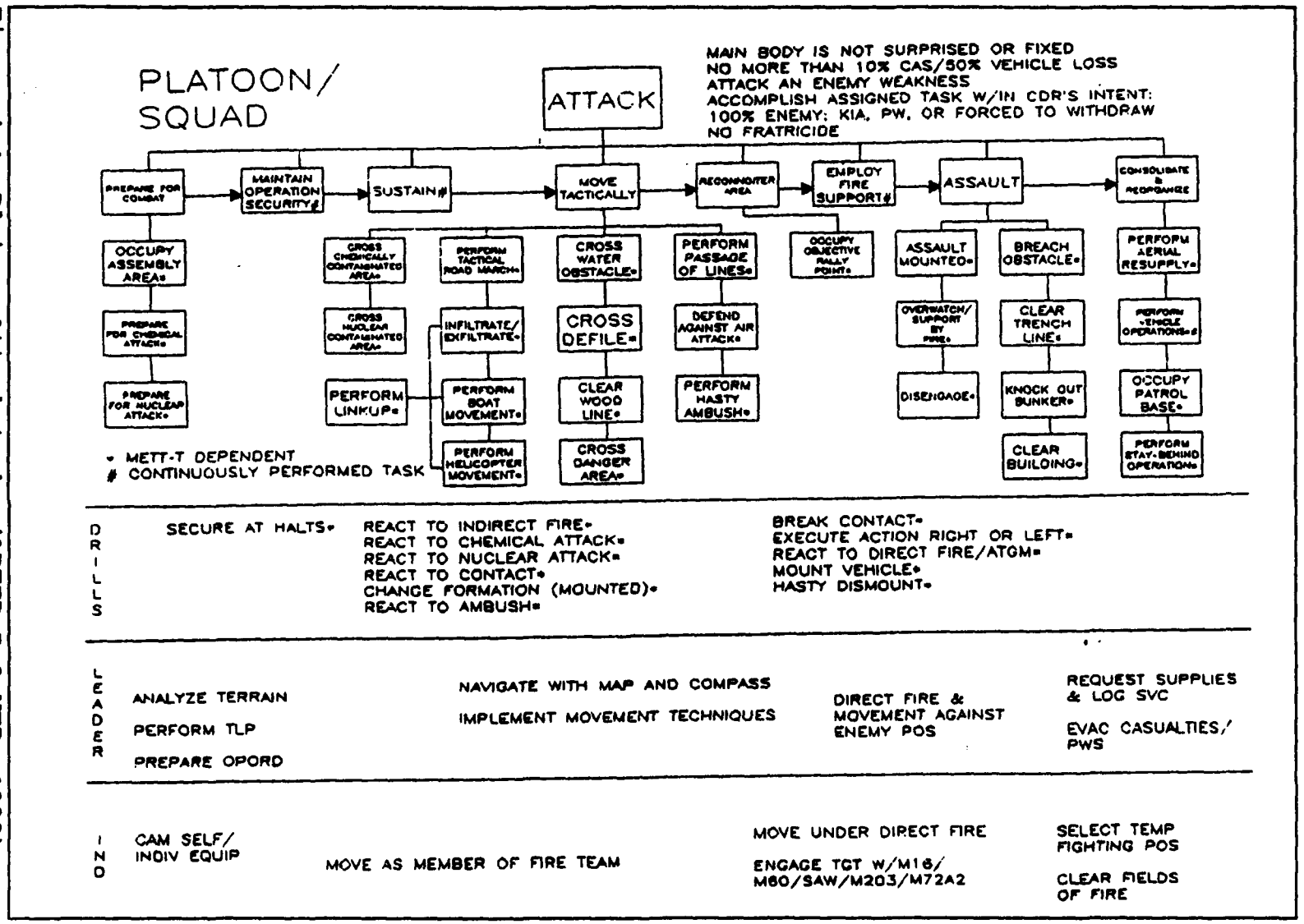

Figure 4-4: Platoon Attack tasks (ARTEP 7-8 MTP, 1988)

Throughout any operation, there are certain collective tasks that the battalion task force must continually perform, regardless of the assigned mission. These common tasks are referred to as the Battlefield Operating Systems (BOS) and apply to all task force missions. Strong emphasis is placed upon the training and evaluation of the tasks since they are essential to the mission success. The tasks which apply throughout and are common to all the operations are:

* Command and control the battalion task force
* Perform intelligence operations
* Employ fire support
* Perform mobility and survivability operations
* Perform air defense
* Perform combat service support operations (71-1, 1988)

E. TRAINING AND EVALUATION STANDARDS

Thus far only the techniques for the training and evaluation have been discussed. However, because of the extensive number of standards published in the Training and Evaluation Outlines (T&EOs) in Army manuals ARTEP 71-2 MTP, ARTEP 71-1 MTP, and ARTEP 7-8 MTP on all the required subtasks, only a sample is presented in this chapter. The Appendix offers larger and more detailed examples of those standards that are set forth for unit evaluation. If additional examples or details on the T&EOs subtasks'

standards are required, the reader should refer to the three MTPs above.

T&EO examples 4-1 and 4-2 on the following pages are only the beginning of the T&EO of those two specific tasks at battalion task force level. The remainder of those particular tasks can be seen in the Appendix. The T&EOs for the company team, platoon, and squad follow the same format of the battalion task force. During evaluation, an objective "Go" or "No Go" is awarded to each subtask. Each subtask has a detailed event that must occur and that subtask must be completed to receive a go. Every required subtask standard, from the initiation of a mission to its termination, is detailed in the T&EOs. A mission of extended duration can have extensive subtasks to complete and pass. Evaluated subtasks start with the individual soldier, continue through the squad and crew, platoon, company team, and battalion staff, and end at the battalion task force commander. These tasks encompass the full range of operations that a unit must be able to complete as part of its critical wartime missions.

MENT: BATTALION TASK FORCE

iK: COMMAND and CONTROL the battalion task force (7-1-3901) (FM 71-2, FM 101-5)

ITERATION 1 2 3 4 5 (circle)

TRAINING STATUS T P U (circle)

CONDITION: The brigade issues an OPORD, warning order, or FRAGO.

TASK STANDARD:

a. The TF plan accomplishes the directed specified tasks IAW the brigade commander's concept and intent. The plan is received and understood by the leadership of the TF. It is coordinated with higher, adjacent, and supporting elements.

b. The TF is prepared to initiate the mission at the directed time.

c. The TF controls and synchronizes subordinate and supporting elements so that it accomplishes the mission and preserves the force.

d. The TF keeps higher, adjacent, subordinate, supporting, and supported headquarters informed.

SUBTASKS AND STANDARDS:	GO	NO-GO
+*1. TF leaders issue the warning order.		
a. A complete warning order is issued within 15 minutes of receipt of the brigade order.		
b. Warning order is received by all platoons within 45 minutes of issuance of battalion warning order.		
*2. TF commander analyzes mission and gives initial guidance.		
a. Guidance includes restated mission, which includes brigade commander's intent for the TF, and identifies all specified and implied tasks.		
b. Guidance includes instructions on information requirements and initially required preparation actions (movement, resupply) to start.		
c. Guidance is given within 30 minutes of receipt of brigade order.		
+3. TF accomplishes reconnaissance and other actions to gather needed information.		
a. Reconnaissance actions begin to physically gain information on the enemy and terrain as early as possible.		
b. Commander/subordinate leaders and staff conduct personal reconnaissance when possible. If not, the commander conducts a detailed map reconnaissance.		
c. Subordinate leaders conduct a personal reconnaissance when possible. See subordinate company and platoon T&EOs.		

T&EO Example 4-1 (ARTEP 71-2 MTP, 1988)

ELEMENT: BATTALION TASK FORCE/MAIN COMMAND POST

TASK: OPERATE main command post (7-1-3904) (FM 71-2, Chapter 2; FC 71-6)

ITERATION 1 2 3 4 5 (circle)

TRAINING STATUS T P U (circle)

CONDITION: The TF performs tactical operations and receives an OPORD, warning order, or FRAGO from brigade.

TASK STANDARD:

a. The main CP plans, coordinates, supervises, and communicates to ensure the successful accomplishment of the assigned mission.

b. The main CP submits required operational/ intelligence reports to the brigade IAW brigade SOP.

c. The main CP is not destroyed.

SUBTASKS AND STANDARDS:	GO	NO-GO
+1. Main CP moves and positions.		
a. CP survives.		
b. Main CP maintains communications with all required stations.		
***+2. Main CP issues warning orders.**		
• Issues a complete warning order to all subordinates and staff within 15 minutes of receipt of a brigade order or instructions from the TF commander to issue a new OPORD.		
***3. TF commander or main CP OIC analyzes mission.**		
a. Brigade and division commanders' intents are identified.		
b. All specified and implied tasks are identified.		
c. Commander is updated within five minutes if he is not located at main CP or aware of brigade order.		
***4. Main CP OIC collects or updates estimates.**		
a. S3, FSE, and combat trains CP provide current and accurate friendly status. Initial status is provided within 15 minutes. Completed estimates are available before commander's war gaming.		
b. S2 provides intelligence estimate, and situational and events templates before commander begins war gaming.		
***5. TF commander or main CP OIC gives initial guidance.**		
a. Restates mission, which includes brigade commanders intent for TF, and identifies all specified and implied tasks.		

T&EO Example 4-2 (ARTEP 71-2 MTP, 1988)

F. SUMMARY

The U.S. Army has devoted significant time and thought into deciding what each unit must accomplish to guarantee success on the battlefield. If a unit completes its evaluation with "Go's", Army leadership feels the unit has an excellent chance of winning in combat. Any equipment, personnel, or procedures added to the battalion task force must also pass the T&EOs (Training & Evaluation Outlines) for combat success. A reorganization of the task force must enhance its ability to perform particular missions more effectively. New navigational equipment might permit the battalion task force to operate better under limited visibility conditions. New communications equipment might allow the unit to pass messages more quickly and securely. Regardless of the equipment on hand and operational, the personnel assigned and structured, and the procedures of operation, a battalion task force must pass the T&EOs.

The standards as outlined in ARTEP 71-2 MTP, ARTEP 71-1 MTP, and ARTEP 7-8 MTP are the basis for evaluating a unit's performance and readiness level. These are the minimum that must be achieved to pass. Should new technology appear that increases the performance of a unit, the unit must still be able to complete the established T&EOs, as a minimum. A unit's performance should increase if properly trained on the equipment. Once trained on the new system, the time required to perform the task should be reduced and the

successful completion rate increased, driving the need for redesigned standards. As necessary, those T&EOs outdated by the advent of new technology can then be updated to new standards. Established T&EOs are the first step reached before new equipment manufacturers can proclaim that the equipment enhances the unit's ability to fight. The systems must be able to meet the currently established standards before introduction into the unit. T&EOs define the minimum standards that provide the baseline for the evaluation of all new equipment destined for the battalion task force and its subordinate units.

In this chapter, examples of the T&EO tasks that an armor or infantry battalion task force must complete, the level the tasks are evaluated at, and the techniques used to execute those evaluations are described. MTPs provide the basis for the evaluation of individual soldier and all echelons through battalion commander. Subordinate unit MTPs support the MTPs of their next higher command level. These MTPs and their assigned T&EOs establish the groundwork for the standards of any new equipment, personnel, or procedures introduced into the battalion task force.

V. CVC^2 ASSESSMENT AND EVALUATION

A. INTRODUCTION

The outcome of combat in the future will depend heavily upon technological advances in weapons systems and weapons supporting systems.(Fu, 1989) Measures for weapons are easier to identify than for weapons supporting systems. C2 systems act as supporting systems for the weapons system and evaluations are usually subjective in nature. However, C2 systems' evaluations are elusive and prove difficult to quantify, thereby making the measures open to dispute since the results are often qualitative. The scope of tests and analysis designed to assess the potential contribution of an automated system, such as CVC^2, should include the administrative, logistical, intelligence, and operational aspects of those planning, execution, and reconstitution activities of at least a battalion task force and its subordinate elements during sustained operations.

As stated previously, the primary goal of C2 is to reduce the uncertainty on the battlefield for the commander. A subsequent goal of improved C2 is the delivery of increased combat power against the enemy. The first step in evaluating CVC^2 is to recognize that CVC^2 is an information system which provides the means to support command and control. It is not an end in itself.

This chapter will address the considerations that must be accounted for in the evaluation of a command and control system. It will examine what the development of the measures of effectiveness (MOEs), measures of performance (MOPs), and measures of force effectiveness (MOFEs) in testing the automated command and control system of CVC^2. It will also discuss the various techniques that may be utilized in the evaluation of CVC^2 using those selected MOEs, MOPs, and MOFEs. The issues of planned use, cost, replicability, and realism are focused upon as they impact upon the evaluation.

B. COMMAND AND CONTROL EVALUATION CONSIDERATIONS

In designing and evaluating a C2 system, six basic characteristics are required to enhance the system's ability to aid the commander. These are:

1. Reliability- The "ability of an item to perform a required function under stated conditions for a specified period of time" mean time between failure (MTBF). (JCS Pub 1, 1987)

2. Survivability- The ability to withstand attacks through hardening, mobility, redundancy, dispersal, and distributed networking. (Martin, 1984)

3. Flexibility- The ability to adapt quickly to changing environments and a wide range of operations and to evolutionary changes to keep pace with state of the art technology. (Bethman, 1989)

4. Responsiveness- The ability to quickly and accurately respond in a timely manner.

5. Interoperability- The ability of "systems ... to provide services to and accept services from other systems ... and to use them to operate effectively together". (JCS Pub 1, 1987)

6. User-orientation- A system designed for the user. It must have "useable information presented or displayed in clear, unambiguous format; and should not require elaborate interpretation". (Martin, 1984)

A major advantage of an automated C2 system is the ability to rapidly execute coordination. This ability to rapidly execute coordination is complementary to the previous six characteristics and can be incorporated into the characteristics of interoperability and the first part of flexibility. Coordination can be organized into and analyzed through four methods of integration: ideology (doctrine), standardization, mutual adjustment (horizontal integration), and direct command and control (vertical integration). The two methods which have the most to gain from an automated C2 system are the mutual adjustment and direct command and control. Mutual adjustment occurs as commanders on the same level horizontally solve their own problems and execute coordination. This reduces the need for vertical information flow and commander's intervention and direction. Direct command and control is

"hierarchically arranged" (Jones, 1992) with the overall commander at the peak of the hierarchy. It is exemplified by the principal of unity of command. This method emphasizes vertical information flow and reduces flexibility.

In designing an automated command and control system, one must consider the many issues that effect the system's planned use and expected performance. The six characteristics previously listed form the first six blocks in constructing the C2 system. These issues establish the framework in the development of the measures for CVC^2 evaluation. For CVC^2, coordination is a primary concern as part of the system's ultimate goal of improving performance.

C. MEASURES DEVELOPMENT

In the development of measures, one should always search for historical examples or existing measures before "reinventing the wheel". The Army has gone through great effort in developing its standards for unit operations and evaluations as described in the previous chapter. These MTPs (Mission Training Plans) serve as the baseline in measures development for new systems. Command and control is one battlefield operating system with existing standards which may serve as the starting point for measures development for a new automated C^2 system. (Refer to Matrix 4-1,4-2, and 4-3, and Example 4-1 in Chapter IV, and the

Appendix). Improved C2 systems strive for the principle objective of improving the commander's decision cycle time by reducing the uncertainty and controlling information about the battlefield. This objective drive all measures development.

One must understand the requirements of the C2 system as defined by the commander prior to selection of measures. The author recommends a simple five step process to assist in this. The first step is to ask the commander what he wants and needs in the system. After understanding the requirements of the system, the second step is to evaluate the unit's operations and procedures exercised through their standard operating procedures (SOPs). The third step is the development of a proposal for the new C2 system that is presented to the commander in the fourth step. Finally, in the fifth step, after making any adjustments suggested by the commander, develop the new C2 system.

Before one can discuss measures development, one must agree on the definition of each measure. A set of measures should be mutually exclusive, collectively exhaustive, and small in number. The following offers a definition for each measure to be addressed.

MOP: the degree to which a particular system accomplishes its mission and other assigned tasks. It describes what a system can do; normally described in

numerical terms, i.e., a cannon can fire 20 rounds per minute under standard conditions.

MOE: a quantitative indicator of the ability of a human, human/machine or machine system to accomplish the task within an operational environment for which it was designed, a "good surrogate for the real goals" (Rockower 1985). For a military force, it is a measure of the force's ability to accomplish its combat mission, i.e., the cannon described above can hit the target 19 of the 20 firings. It must reflect the objective, be targeted at the appropriate level, and be kept simple. Some examples of typical MOEs include:

*number of enemy casualties

*number of friendly casualties

*time to accomplish mission

*rate of advance or withdrawal

*scenario dependent

MOFE: the measure of how well a system and its parent force perform their missions (Metersky, Sovereign, and Sweet 1985). The measure gauges the system's contribution to the total effectiveness of overall battle outcome, i.e., the cannon successfully defeated the enemy attack.

Since CVC^2 is an automated C2 system, only measures for the evaluation of command and control are developed. Target acquisition and engagement are not addressed. With modern direct fire gun systems, it is assumed that the if

the target can be seen and identified and assigned to a weapons system for engagement, it can be hit and killed.

D. MEASURES

The criteria, hypotheses, and measures listed below are based upon the extractions from several documents on command and control system's evaluation. These documents include: Combat Vehicle Command and Control Battalion-Level Preliminary Evaluation (1992), M1A2 Adjunct Analysis (IVIS Volume) (1992), CVC^2 Criterion Measures Categories (1992), Test and Evaluation Plan for the M1A2 Abrams Tank Early User Test and Experimentation (1991), Test and Evaluation Plan for Maneuver Control System (MCS) Early User Test and Experimentation (EUTE) (versions 1992 and 1993).

These documents provided the foundation for the criteria, hypotheses, and measures selected for CVC^2's evaluation. Those indexed relate back to the overall objective of CVC^2, which is to reduce the commander's decision cycle time by reducing the uncertainty and controlling the chaos of the battlefield. The measures created had to pertain to a battalion task force in the execution of a combat operation that included all three phases of battle: planning, execution, and consolidation and reorganization. Refer to the diagram in Figure 5-1 for the relationship between the objective, criteria, hypotheses, and measures.

Figure 5-1 shows the path from the overall objective of improving the commander's decision cycle time to each measure used to evaluate CVC^2's ability to achieve that objective. Each numbered criteria, hypothesis, and measure is described on the following pages beginning on page 81. The path originates with the objective and flows to the two criteria (numbers 1 & 2), which is further broken down into hypotheses. Rejection or non-rejection of these seven hypotheses (numbered 1A through 7) serve to support or denounce the objective. To evaluate the hypotheses, measures are developed for each hypothesis. These measures are numbered 1A-1 through 7-8. In this method, each measure can be traced back through the path to the hypothesis and criteria its supports, and to the objective.

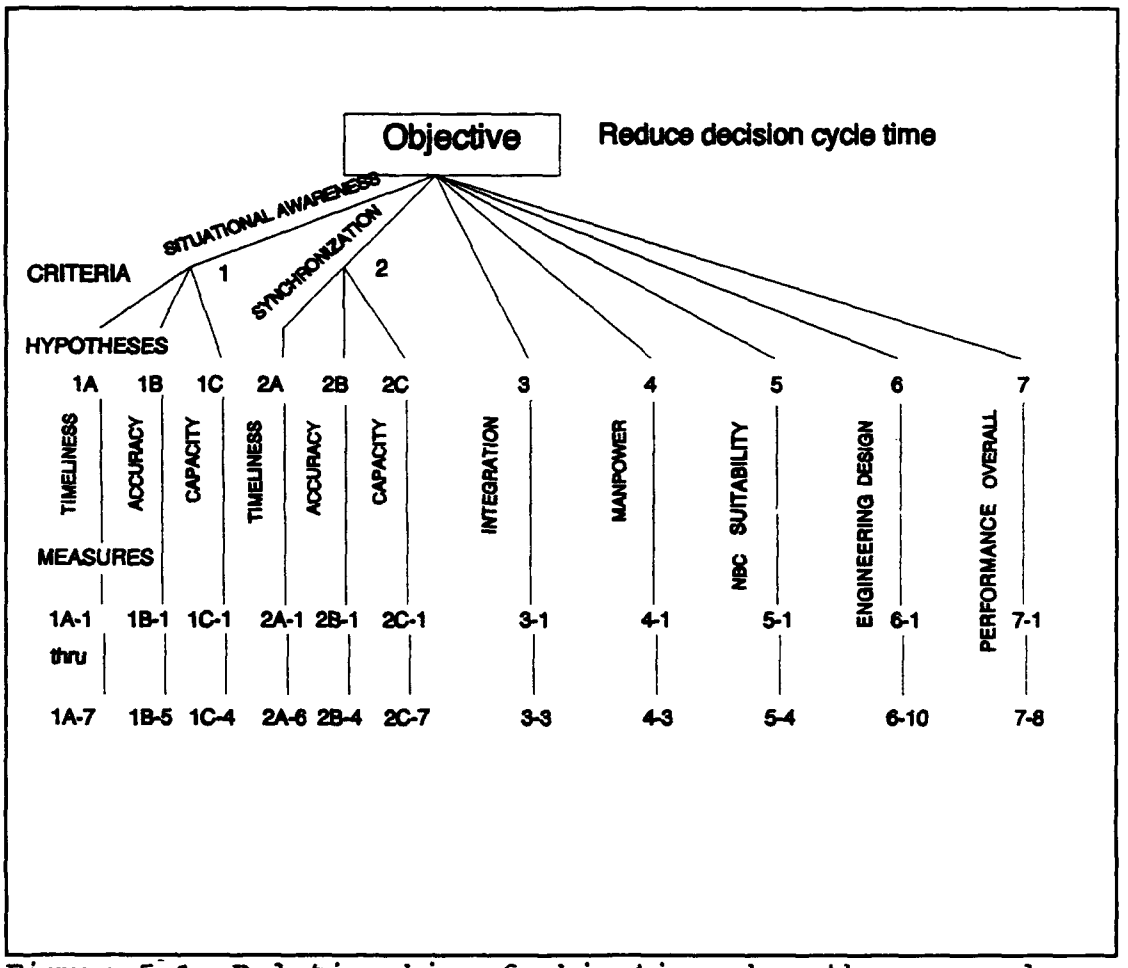

Figure 5-1: Relationship of objective, hypotheses, and measures

In the following discussion of measures the reference to "reports" is made numerous times. This is done to simplify the measures descriptions. Whenever "reports" is listed, it is to equate to all operational, administrative, logistical, intelligence, NBC, and shell reports, overlays, orders, and calls for fire. Basically, any message traffic whether text or graphics is lumped into "reports".

The scenario used to evaluate the following measures involves one maneuver brigade operating with atleast two battalion task forces. Each battalion task force is equipped with identical equipment and personnel levels. However, one of the battalion task forces shall be equipped with CVC^2 throughout its units. Headquarters, field artillery, combat engineers, air defense, and air assets composing the normal battalion and brigade combat, combat support, and combat service support elements will be operational to support the battalion task forces.

MOE #1: Amount of time CVC^2 reduces the commander's decision cycle time by improving his situational awareness, and thereby increasing the rate of mission success.

MOFE #1: Amount of time CVC^2 decreases the unit's planning and execution time, increasing the rate of mission success.

CRITERIA #1: CVC^2 enhances a unit's timeliness by providing accurate situational awareness information to all CVC^2 equipped units at all echelons during planning, execution, and reconstitution phases of the decision making process.

HYPOTHESIS #1A: CVC^2 enhances the timeliness of situational awareness information by decreasing the time it

takes for the information to pass from the observer to the commander.

MOP #1A-1: Number of user attempts required to perform basic CVC^2 tasks successfully.

MOP #1A-2: Time to perform basic CVC2 tasks successfully.

MOP #1A-3: Time from one CVC2 CID (Commander's Information Display) data base update comprising each report to a corresponding update at other CIDs.

MOP 1A-4: Time from unit location change until the CIDs within and between echelons report the new location.

MOP 1A-5: Time from unit status change until the CIDs within and between echelons report the new status.

MOP 1A-6: Time from transmission to actual reception by the leader who needs the information of critical data for the decision-making process.

MOP 1A-7: Time from transmission to actual reception by the person who needs the information.

HYPOTHESIS 1B: CVC^2 enhances the accuracy of situational awareness information.

MOP 1B-1: Accuracy of data from one CVC^2 CID data base update comprising each report to a corresponding update at other CIDs.

MOP 1B-2: Percent of agreement between data base unit status and command post mapboard unit status within the same command post.

MOP 1B-3: Percent of agreement between data base unit location and command post mapboard unit locations within the same command post.

MOP 1B-4: Percent of data that is critical to decision-making process which is correctly flagged and processed and delivered to the person who needs the information.

MOP 1B-5: Percent of data that is perishable which is correctly flagged, prioritized, processed and delivered to the leader who needs the information.

HYPOTHESIS 1C: CVC^2 enhances the information flow of situational awareness information.

HYPOTHESIS #2C: CVC^2 enhances the information flow for synchronization of combat operations.

MOP 2C-1: Number of formatted reports existing in data base which are transmitted.

MOP 2C-2: Number of unformatted reports or voice messages which are transmitted.

MOP 2C-3: Percent of reports retrieved from database.

MOP 2C-4: Percent of leaders and staff expressing belief that CVC^2 enhances the commander's ability to synchronize combat operations.

MOP 2C-5: Percent of message traffic transmitted through CVC^2.

MOP 2C-6: Percent of C2 analysis functions which could be performed using CVC^2 that are actually accomplished by other means during planning, execution, and reconstitution phases.

MOP 2C-7: Percent of leaders and staff users expressing belief that CVC^2 improves the capability of subordinate leaders to take initiative in synchronizing battle actions during planning, execution, and reconstitution phases.

HYPOTHESIS #3: CVC^2 training prepares leaders and staff users to integrate CVC^2 C2 tools and functions into the performance of their C2 duties.

MOP 3-1: Percent of total message traffic transmitted through CVC^2.

MOP 3-2: Percent of C2 analysis functions which are supported by CVC^2 during the planning, execution, and reconstitution phases.

MOP 3-3: Percent of times the lack of use of CVC^2 is attributed to a training deficiency.

HYPOTHESIS #4: CVC^2 does not increase the operational burden on leaders and staff.

MOP 4-1: Number of hours for CVC^2 users per day for on-duty time working, on-duty time not working, and CVC^2 usage time.

MOP 4-2: Number of soldiers assigned to CVC^2 operations. (compared to non-CVC^2 operations).

MOP 4-3: Ratings and comments of users about adequacy of manpower.

HYPOTHESIS #5: Wearing of NBC and environmental protective clothing does not degrade operations of CVC^2.

MOP 5-1: Time to select, format, and send a CVC^2 report. (with and without protective clothing).

MOP 5-2: Time to retrieve and reply to a CVC^2 report. (with and without protective clothing).

MOP 5-3: Operator time to perform basic CVC^2 tasks successfully. (with and without protective clothing).

MOP 5-4: Percent of scheduled tasks completed during a predetermined shift period. (with and without protective clothing).

HYPOTHESIS #6: CVC^2 human engineering design supports effective performance of C2 tasks.

MOP 6-1: Number of attempts to perform basic tasks.

MOP 6-2: Operator time to perform basic tasks.

MOP 6-3: Time from one CID update of data base comprising each report to a corresponding update at other CIDs between and within echelons.

HYPOTHESIS #7: CVC^2 enhances overall mission performance through the planning, execution, and reconstitution phases.

MOP 7-1: Number of missions successfully completed.

MOP 7-2: Time to complete each mission.

MOP 7-3: Percent of enemy vehicles killed by friendly forces.

MOP 7-4: Number of fratricide hits and kills.

MOP 7-5: Dispersion distance of individual vehicles while maneuvering.

MOP 7-6: Average velocity of individual vehicles while maneuvering.

MOP 7-7: Average amount of fuel consumed by individual vehicles.

MOP 7-8: Number of times a vehicle is out of assigned sector.

The previous several pages outlined the measures to be used in the evaluation of CVC^2. Those measures when tested

in the scenario and environment described provide the measures and techniques necessary to properly examine the ability of CVC^2 to reduce the commander's decision cycle time by reducing uncertainty and controling information about the battlefield.

The introduction of a new automated command and control system can be detrimental to the unit's C2 performance. Leaders can be distracted from their primary responsibility of leading the soldiers and directing the battle by becoming overly focused on the system updates. Enhancements of timeliness, accuracy, and information flow can be hindered instead of improved if the system is not utilized as designed. These issues, or distractors, are discussed in Chapter VII.

E. EVALUATION TECHNIQUES

In the history of modern warfare, the procurement, test, and evaluation of C3I systems has always been a difficult process. New systems being developed, as well as older systems undergoing modernization, are becoming increasingly complex and expensive. In order to meet an increasingly technologically complex threat, the projected environments in which these systems must perform are driving the complexity of our automated systems. As a result, the performance of these systems in a wartime operational environment has become difficult, if not impossible, to

emulate. Neither traditional development nor operational testing alone can fully address C3I system performance issues because of the inability to characterize the projected environment. In addition to the inherent level of system complexity and the increasing synergy among these systems, the testing of C3I systems is subject to significant peacetime constraints, including cost, environmental restrictions, operational security, and human factors. These factors will dictate an increased sensitivity to operational suitability issues in the future dealing with modernization. (Illgen, 1990)

In order to properly analysis a C2 system, one must have the capability to gather data on the selected MOEs and MOPs. The following describes a variety of methods to collect that data.

1. Modeling: "A model is a simplified representation of the entity it imitates or simulates." (Hughes, 1984)

2. Experimentation: The process of conducting tests or trials to verify or invalidate a hypothesis.

3. Simulations and War Games: These can be either manual or computer assisted and can be executed repetitively in short periods of time. The data is only as good as the inputs into the simulation or war game." (Bethman, 1989)

4. Exercise Data: Information collected from military field exercises can be very useful. However, field problems do not truly reflect combat, can not be replicated, and are

TECHNIQUE	COST	LEAD-TIME	REPLICABILITY	REALISM
COMBAT/ CRISIS	N/A	N/A	NONE	YES
CTCs	VERY HIGH	2-3 YEARS	LITTLE	VERY HIGH
CPX/CFX/ FTX /STX	HIGH / MODERATE	1-2 YEARS	LITTLE	GOOD
WARGAME/ BATTLE SIMULATION	HIGH	1-2 YEARS	LIMITED	FAIR
TEST BEDS	MODERATE	1-2 YEARS	YES	LIMITED
LABORATORY SIMULATION / EXPERIMENT	MODERATE	1/2-1 YEAR	YES	SELECTED VARIABLES
COMPUTER ANALYSIS	LOW	1/2-1 YEAR	FULLY	VERY LITTLE
ANALYSIS	VERY LOW	WEEKS	FULLY	VERY LITTLE

TABLE 5-1: REALISM VERSUS COST

Command and control systems such as CVC^2 lend themselves to testing with reduced field exercises and soldier involvement because they do not require the firing of weapons for evaluation. SIMNET at Fort Knox Close Combat Test Bed presents a fine example of how simulation can be used for C2 system evaluation. However, SIMNET does not permit the evaluation of the full potential of CVC^2. All three phases of combat; planning, execution, and reconstitution, must be examined at the levels of platoon through battalion. SIMNET permits the evaluation of only the execution phase at only one company level.

Because of the significant contribution an automated tactical C2 system makes to the Army, higher evaluation costs should be accepted. Training, along with limited evaluations, for the use of CVC^2 can occur with computer simulations. Synthetic environments, such as SIMNET tied into virtual reality simulators will provide a more realistic, slightly higher cost evaluations. However, although "operational testing is limited by time, funds, and ranges or training areas available, actual system testing with typical operators will always be required." (Hardy, 1992)

The Army's C2 system is comprised of a combined arms team consisting of elements from all branches. To achieve the desired combat effectiveness a high degree of coordination and synchronization is needed. A good final

test and evaluation scenario would involve a standard maneuver brigade with two or three battalion task forces. Two of the three battalions would be like units, one equipped with CVC^2, one without. All else, equipment and personnel levels, would be identical. The brigade should have normal combat support and combat service support to include artillery, engineers, air, and air defense assets. An environment similar to those executed at the National Training Center (NTC) is the most preferable.

The National Training Center currently offers the most realistic environment, short of actual combat, for evaluating a new C2 system. Although NTC is a training center and not a testing center, its time may have come to assist in testing evaluation. As the Army reduces in size the number of operational units and active installations, fewer locations exist for testing evaluation. Additionally, fewer units will be available to rotate through the NTC. This will open up time in the center's schedule for testing evaluation. It will also enhance its reason for existence in the light of the decreased Warsaw Pact massive assault it was designed to train units to fight against. This would eliminate any non-use time at the center and compensate for the loss of other manuever and testing areas.

The center is configured with sensors throughout the manuever area to record massive amounts of data from individual soldiers and vehicles through brigade level

operations. With the instrumentation already in place, time and money would be saved by not having to install the sensor equipment at another location. Working in conjunction with the instrumentation, are the Observer-Controllers who require no additional training to work with the CVC^2 equipped battalion. Their techniques would remain the same for all units. A well trained Opposing Forces (OPFOR) unit already exists at NTC for friendly CVC^2 equipped units to combat. The rotation's duration of two weeks is sufficiently long enough to fully exercise the system. During the evaluation, around the clock operations are conducted, allowing no let up during the two weeks. In addition to the force on force exercises at NTC, units conduct live fire exercises.

NTC provides the opportunity to evaluate all the MOPs, MOEs, and MOFEs in a realistic combat environment. It can be controlled, does not require additional time and money to create the test evaluation range or manuever area, and is the next best thing to actual combat.

F. SUMMARY

This chapter examined the considerations that must be addressed in the development of C2 evaluation criteria. It discussed the development of those measures and presented the MOEs, MOPs, and MOFEs that should be considered when examining CVC^2. Finally, the chapter analyzed the various

evaluation techniques for a new C2 system. One must keep in mind that CVC^2 is a command and control system, not a weapons system. The increase in the total number of enemy vehicles or soldiers killed versus the total number of friendly vehicles or soldiers killed is only one measure for consideration. Improved C2 systems strive for the primary objective of reducing the commander's uncertainty about the battlefield. This objective drives all measures development. Once the measures are developed, the actual evaluation can occur. Several methods exist for CVC^2 evaluation, from analysis to combat training centers. Simulations offer different techniques for evaluation, but can not replace the ultimate need for operational testing with real soldiers under realistic conditions.

To ensure that tactical uncertainty exists during the system's evaluation, chaos must be permitted to enter "the play". Freeplay must be allowed to demonstrate if units get lost or cause fratricide. The new system is supposed to reduce the occurrences of both. The unit and maneuver scale must be large enough. For CVC^2, this means at least one battalion with the appropriate maneuver area. The scenarios of several battles must be long enough without pauses for data collection to introduce fatigue and time constraints. During the evaluation, the only thing that should be controlled is the scenario through the assigned mission tasks. A new command and control system can not be properly

or adequately tested in a laboratory or workshop. CVC^2 must have the man-in-the-loop with all the uncertainty and chaos of today's battlefield.

VI. BENEFITS OF CVC^2

A. INTRODUCTION

Incorporating an automated command and control system into the command and control process offers many benefits to the units that possess and utilize that system. CVC^2 provides benefits at the various levels of command, phases of battle, and battlefield operating systems discussed in earlier chapters. Although each level and function may benefit at each phase of the battle, this chapter will discuss those functions and levels which benefit the greatest from the use of CVC^2. The three phases of battle (planning, execution, reconstitution) will be examined in regards to the seven battlefield operating systems (combat service support, command and control, mobility/survivability, manuever, air defense, intelligence, fire support) and the levels of command (vehicle/crew, platoon, company, battalion) within the battalion task force. Figure 6-1 graphically represents the relationship between the phases of battle, levels of command, and the battlefield operating systems. CVC^2 enhances the unit's ability in each individual "cube" so that eventually the battalion task force's ability to conduct the larger entire "cube" is improved. The "cube" will be used throughout this chapter to help explain the association between the phases, levels, and systems.

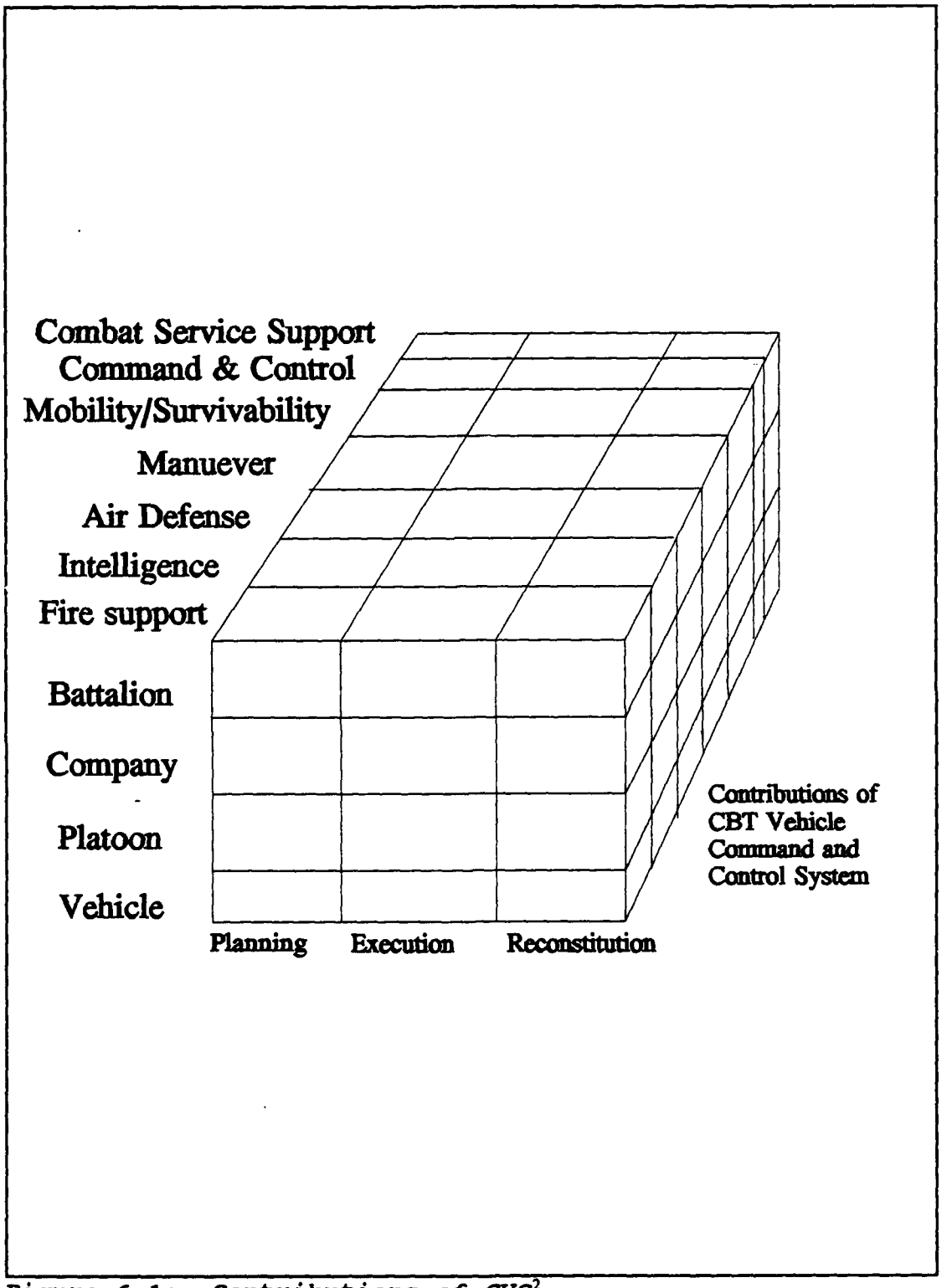

Figure 6-1: Contributions of CVC^2

B. PLANNING

The use of CVC^2 in the planning phase reveals the greatest benefit for the unit, regardless of its level. A unit that develops a better plan and issues that plan to its soldiers, with the soldiers understanding that plan, will require less command and control during the actual execution of the battle. Subordinate leaders and soldiers that have a clear understanding of the commander's intent, concept of operations, and the responsibilities of subordinate units do not require constant supervision during the execution phase. A unit that requires less clarification of orders and direction from superiors will be able to execute their tasks more swiftly and gain the advantage of time. CVC^2 aids in this planning process by providing clarity of the plan with text and graphics based upon the most recent friendly and enemy status' and locations and timeliness of the plan's issuance. It allows planners to "optimize the use of time by routine use of warning orders, situation updates, and anticipatory planning and positioning of forces"(FM100-5, 1986).

In the planning phase, company and battalion levels gain the most from an automated command and control system. Individual vehicle crews and platoons do much of their planning face to face with their soldiers because it is the lowest level of command and the proximity of soldiers and vehicles to one another. A company and battalion is much

more dispersed than the platoon and can not always get the necessary leaders together to formulate a plan. These leaders might also be in the process of executing the current mission. Figures 6-2a through 6-2d offer a comparison between the different levels of command and battlefield operating systems as to the benefits of each in the planning phase. Although each level of command gain in each battlefield operating system, only those with the most significant benefit are highlighted. "Overall the greatest contribution of CVC2 appears to be in the "Planning" function of the C^2 process"(Miller,1992).

Combat service support is carried out primarily at the company and battalion level while the platoons and vehicle crews report their status. At this phase, command and control is conducted in person at the lower two levels while command and control is conducted over radio or wire at the higher two levels. As part of mobility/survivability, each level needs to report the locations of enemy and natural obstacles and the initiation and completion of friendly obstacles. Manuever covers a unit's plans of attack routes or fighting positions as each level of command must plan for their offensive and defensive movement. Air defense is planned principally at the battalion level. A unit at each level can not properly plan its next mission without accurate intelligence on enemy and friendly units, such as size, activity, location, equipment, and mission. Fire

support planning for indirect fires is conducted by the platoon leadership and higher commands, while the battalion staff also plans for close air support. Vehicle crews execute their platoon and company indirect fire support plans.

The cube diagrams represent a three dimensional relationship between the levels of command, phases of battle, and battlefield operating systems. For example in Figure 6-2a, at the vehicle level of command during the planning phase, the battlefield operating systems of intelligence, maneuver, and mobility/survivability gain the largest benefits. In Figure 6-2b, at the platoon level of command during the planning phase, the battlefield operating systems of fire support, intelligence, maneuver, and mobility/survivability reap the largest benefits.

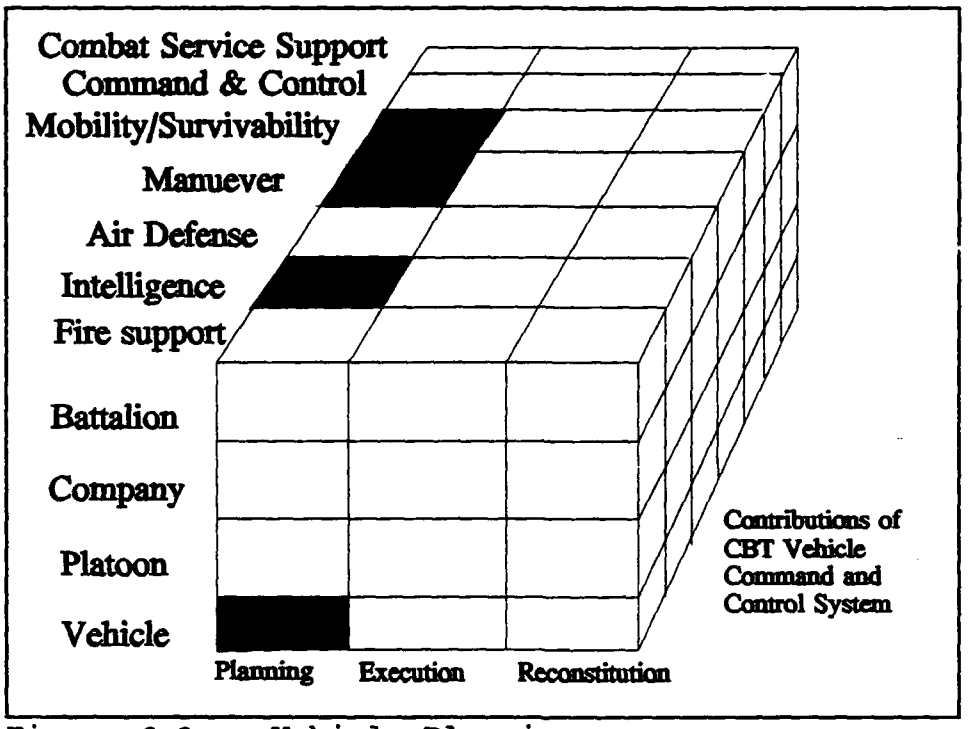

Figure 6-2a: Vehicle Planning

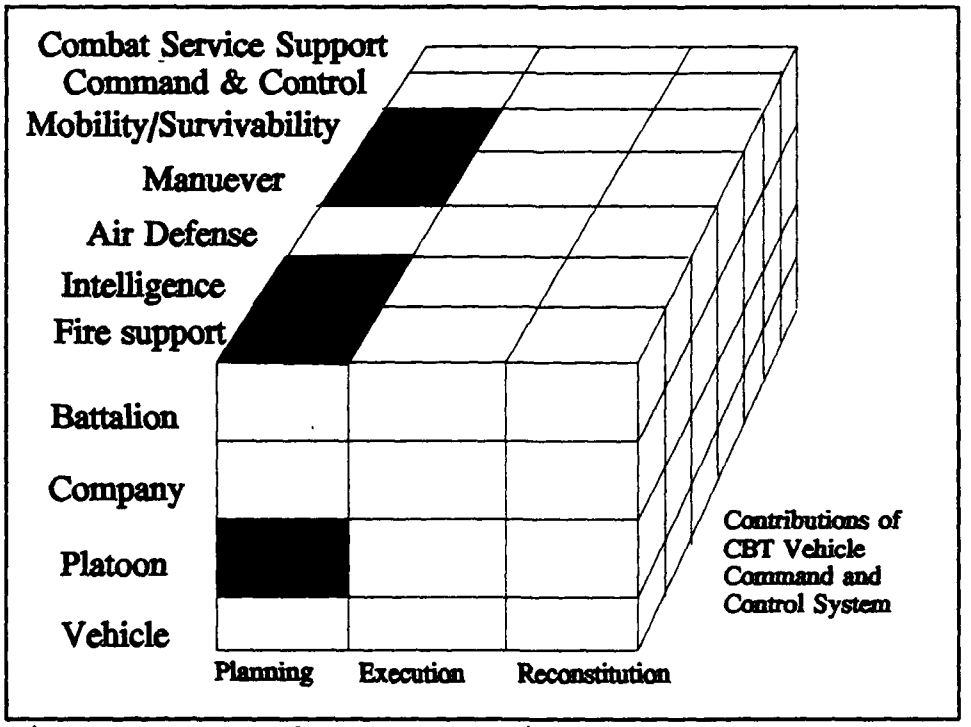

Figure 6-2b: Platoon Planning

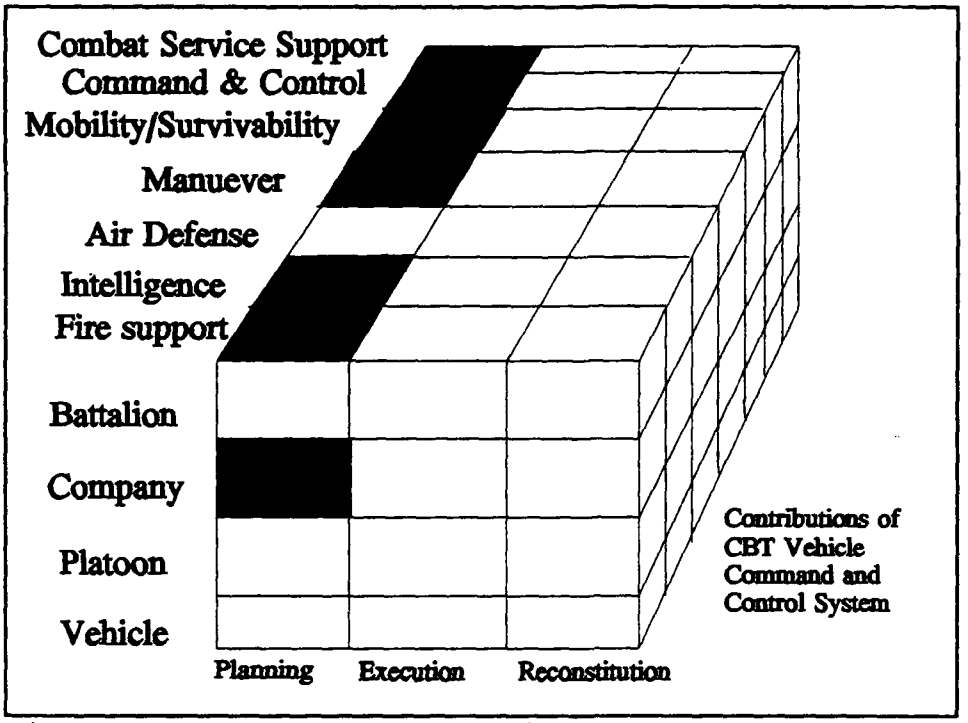

Figure 6-2c: Company Planning

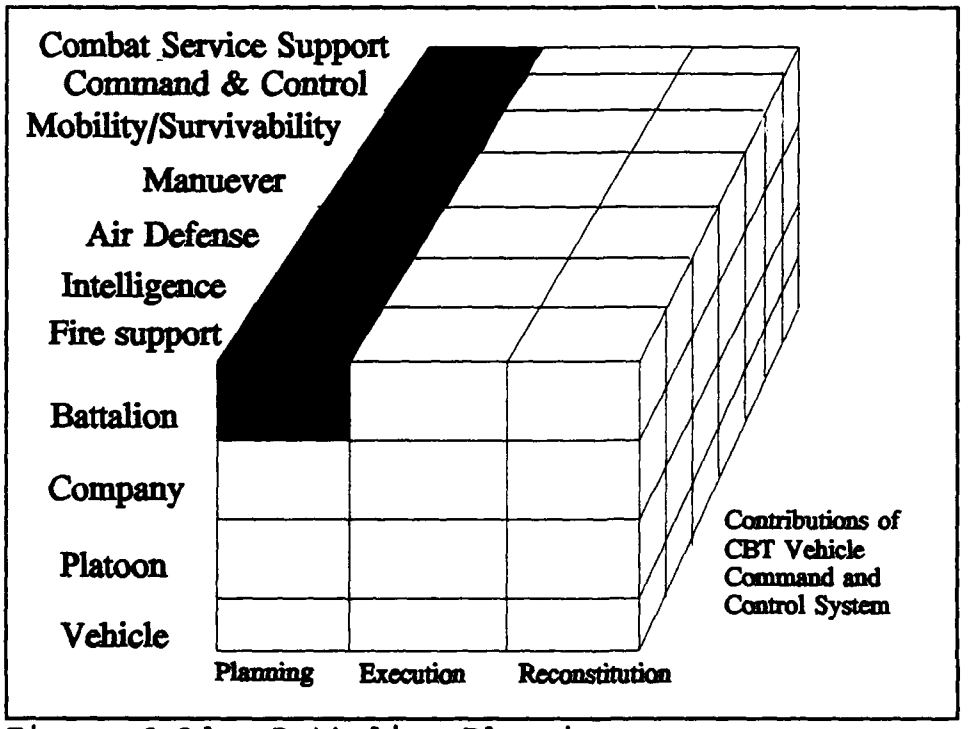

Figure 6-2d: Battalion Planning

C. EXECUTION

If a mission is properly planned, disseminated, and understood, this phase becomes slightly easier. A unit is more flexible and better able to react to enemy actions and more swiftly execute their own to retain the initiative. Army doctrine specifies that "tactical offenses are rapid, violent operations that seek enemy soft spots, rapidly shift the main effort, and exploit successes promptly"(FM100-5, 1986). CVC^2 permits a unit to execute its mission in just such an environment. Refer to Figures 6-3a through 6-3d for a comparison of the levels of command and operating systems in the execution phase.

During the execution of a mission, the combat service support is essentially executed at battalion level, while company level and below are fighting the battle. A platoon controlling four vehicles or a battalion controlling fifty require swift and constant command over their unit. Successful and complete command and control is imperative to mission accomplishment. CVC^2 will permit the necessary control with rapidly transmitted graphics and message text. In mission execution, all levels of command need accurate information on any obstacle so that the obstacle may be avoided and not delay or prohibit mission accomplishment.

Manuever is the largest element of the execution phase and of extreme importance to each level of command. CVC^2 permits timely reporting and control of each unit's manuever

to their superior commands. Accurate position reporting allows each commander a better "picture of the battlefield". As in the planning phase, air defense remains the primary responsibility at battalion level.

Timely, accurate, clear, and useful intelligence on enemy and friendly locations and actions is essential to all levels of command. During a mission, the unit requires only intelligence that may impact upon their mission. "Dumping" too much intelligence on a unit is as bad as not giving any at all. Units must be able to process the intelligence passed from all levels of command. This intelligence flow can be controlled by the leaders at each level as they validate and collate the information into a useful intelligence package.

Being able to digitally request fire support over CVC^2 will greatly speed up the process for indirect fires. Leaders at each level will be able to see the fire missions requested by other units. This will prevent redundancy in indirect fire support missions, permit consolidation at higher levels for the support, and provide an additional method of presenting the enemy's order of battle.

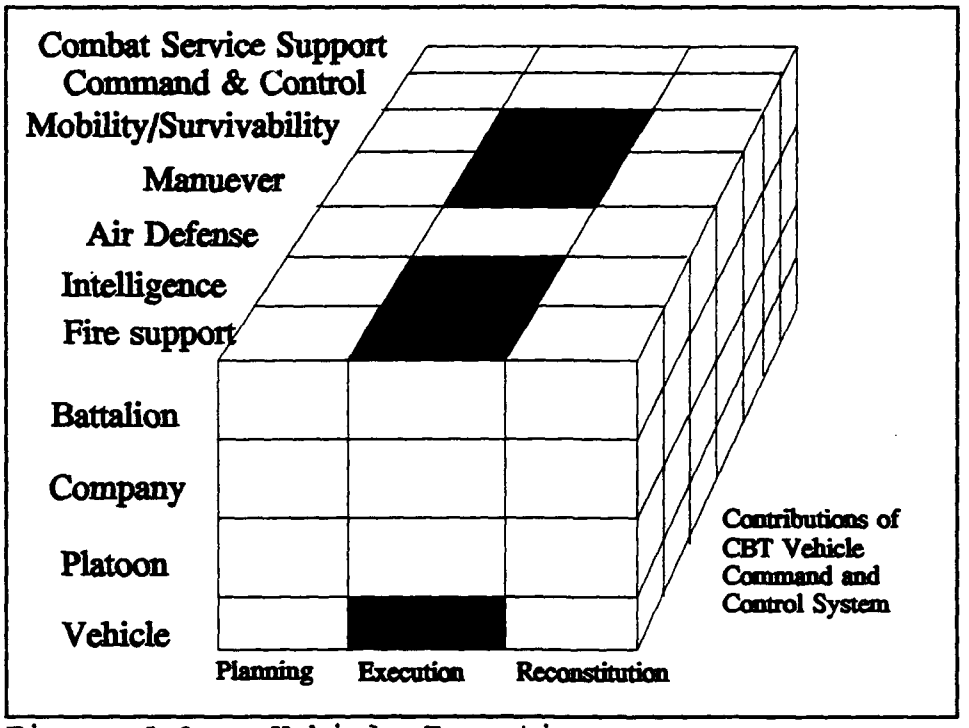

Figure 6-3a: Vehicle Execution

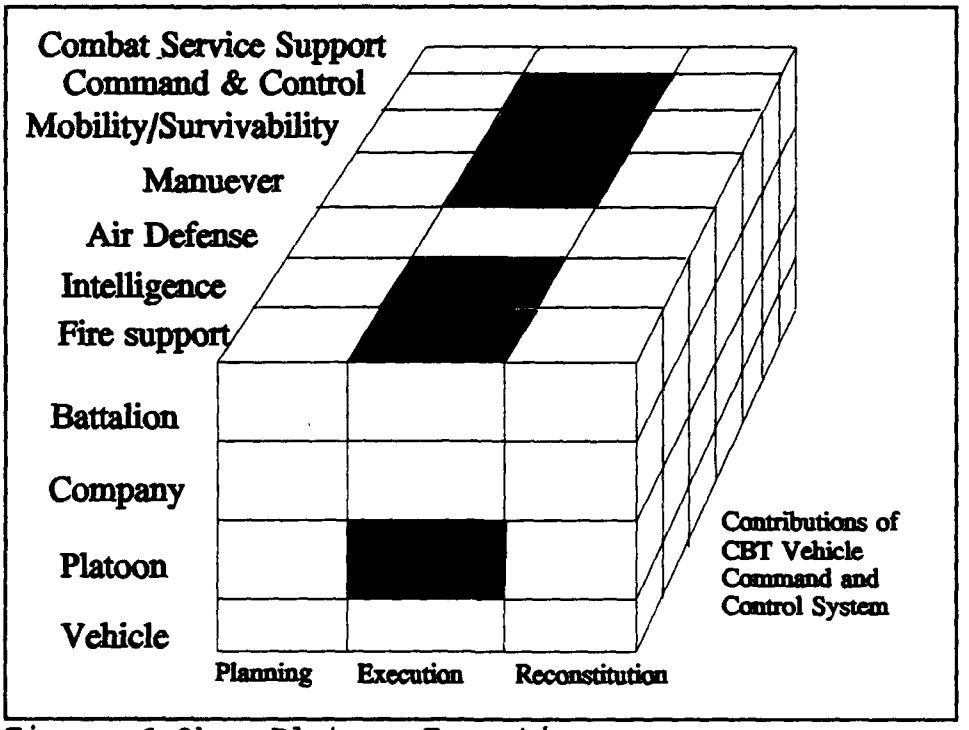

Figure 6-3b: Platoon Execution

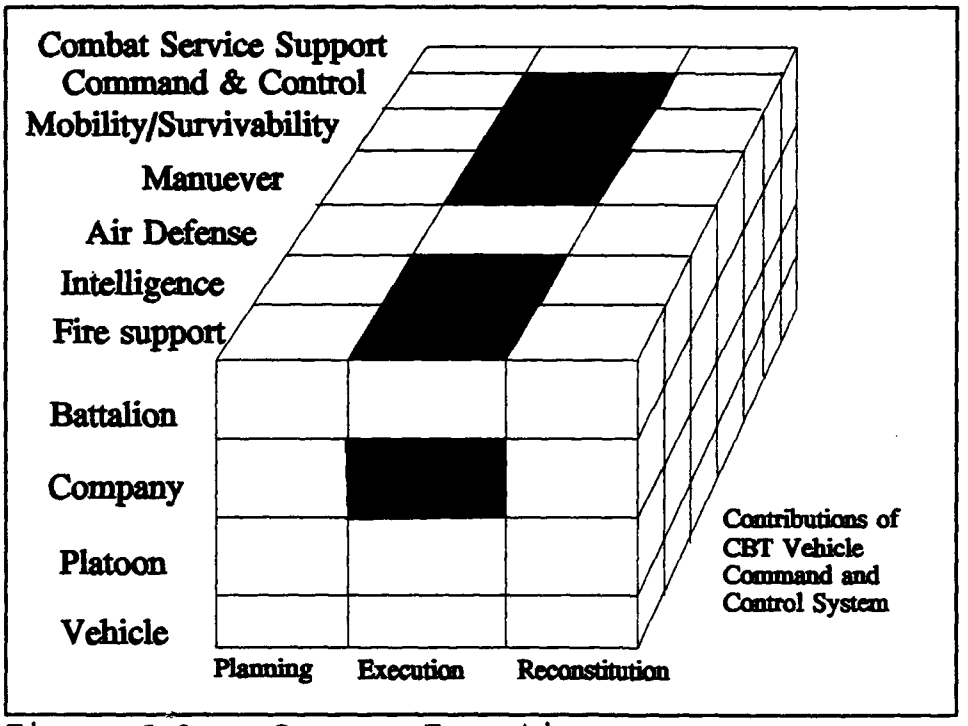

Figure 6-3c: Company Execution

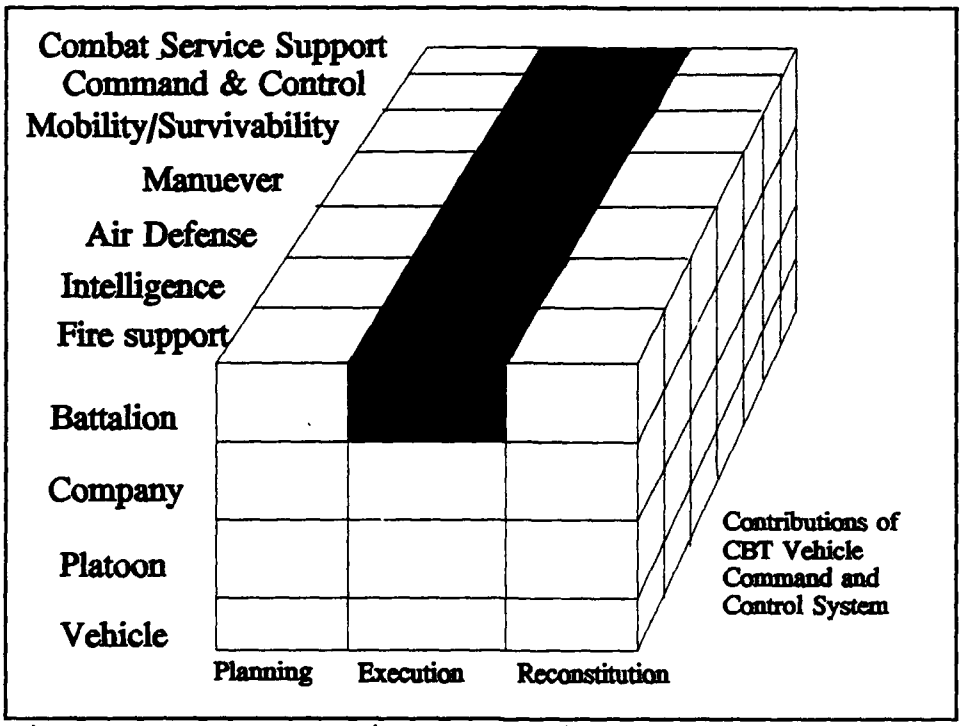

Figure 6-3d: Battalion Execution

D. RECONSTITUTION

"Reconstitution is focused action to restore ineffective units to a specified level of combat operations"(FM100-5, 1986). This may include personnel, supply, or equipment replacement and reestablishment of the chain of command. In this phase the greatest gain for all levels is combat service support as evidenced in Figures 6-4a through 6-4d.

In the past, combat service support was done almost entirely by voice message and paper copies. With CVC^2, units can prepare their personnel, ammunition, and vehicle status reports and transmit the report with the push of a single button. The whole process is quicker since leaders at each level do not have to transmit each combat service support report individually over the radio. A process which currently takes an inordinate amount of time. Units will no longer have to guess the locations of damaged, destroyed, or missing vehicles as they can be located based upon their ast automatically updated position by CVC^2 during the battle. At all levels of command, intelligence on the locations of friendly combat service support elements, friendly combat units, and the enemy situation impact upon the effectiveness of reconstitution. Command and control during this phase is conducted face to face at crew and platoon levels, while command and control at company and battalion is conducted over radio or wire. As with the planning and execution

phases, battalion must coordinate for the unit's air defense measures during reconstitution.

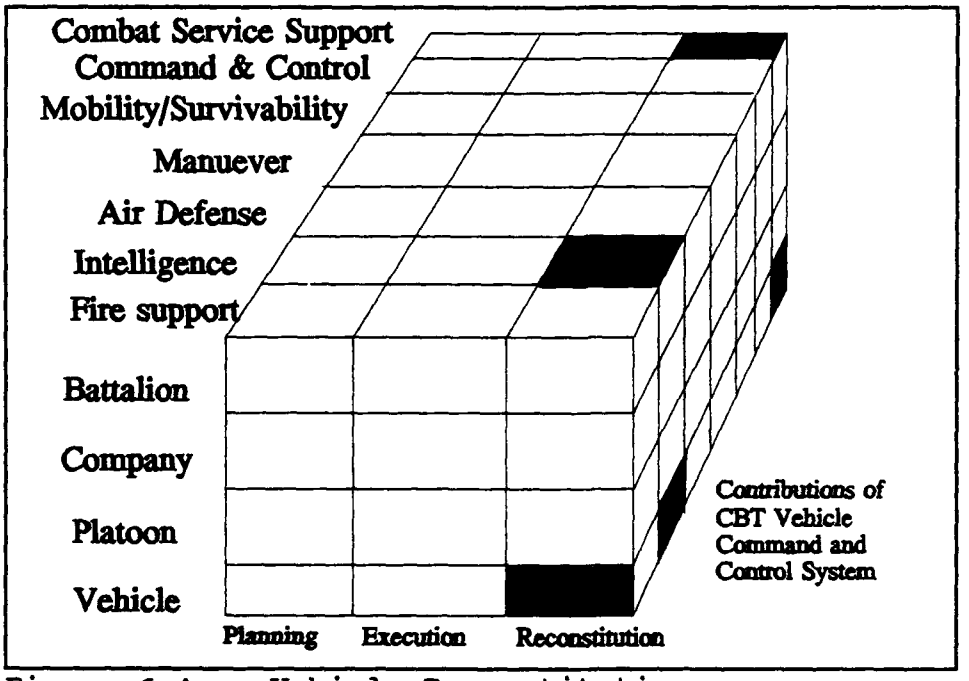

Figure 6-4a: Vehicle Reconstitution

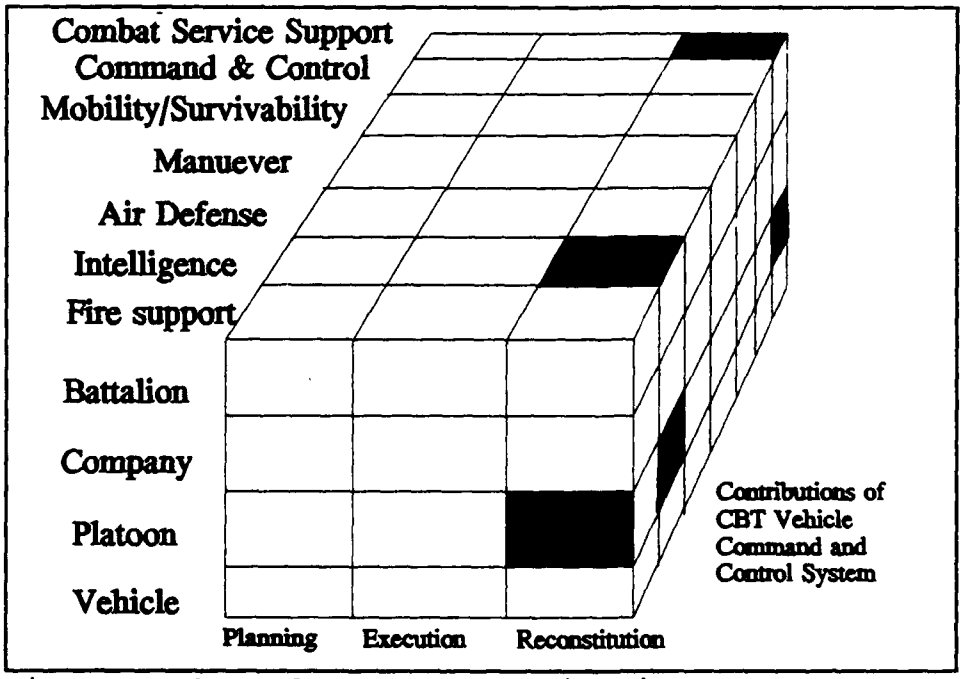

Figure 6-4b: Platoon Reconstitution

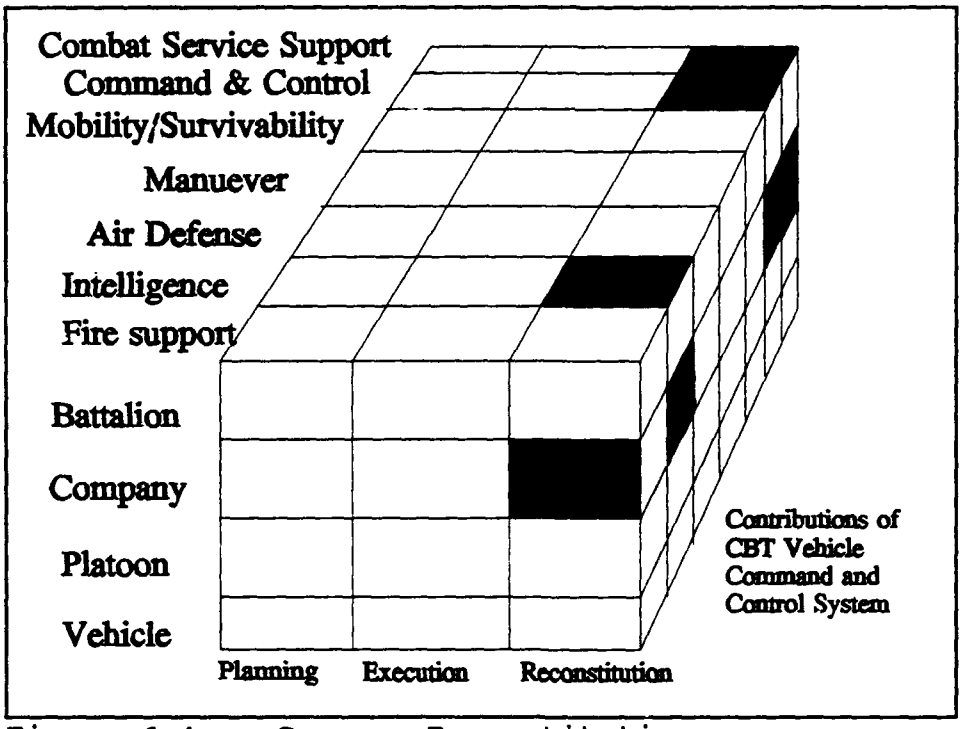

Figure 6-4c: Company Reconstitution

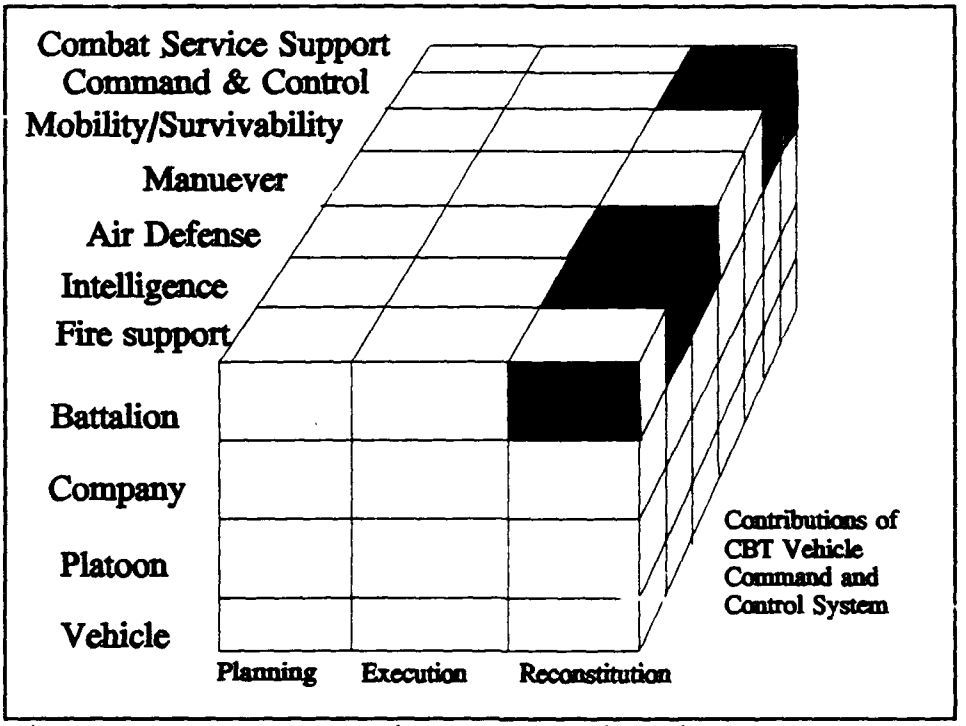

Figure 6-4d: Battalion Reconstitution

E. SUMMARY

CVC^2 offers significant benefits to each level of command in the seven battlefield operating systems during each phase of battle. In this chapter however, only the most significant contributions in each area were highlighted. The CVC^2 contribution cube allows a graphical representation of each particular area's contribution. The levels, systems, and phases are closely interrelated and must be examined together to properly evaluate the benefits from an automated command and control system. The benefits from CVC^2 are great and will enhance any unit's ability to quickly and successfully accomplish its mission.

VII. CONCLUSIONS

A. RETROSPECT

This thesis examined the development of the measures and techniques required to evaluate a new tactical command and control system for the battalion and below. CVC^2 provides an opportunity to evaluate a new C2 system where measures have not previously been selected. As C2 measures are difficult to quantify in concrete values and numerical figures, measures must be carefully chosen. The first step is to ascertain what the tactical commander requires for C2 improvement. After resolving those requirements, measures can be created with the foundation being the measures already in existence in the Mission Training Plans (MTPs).

In order to establish an understanding of CVC^2 and the inputs and outputs of an automated C2 system, a description of the hardware components is furnished in Chapter II and factors involved in the C2 process are described in Chapter III. Chapter IV discussed the MTPs that serve as the baseline for CVC^2 evaluation. The measures listed in Chapter V detail those measures that should be used in CVC^2 evaluation. All levels of command gain from an automated C2 system as highlighted in Chapter VI.

No one evaluation technique is adequate for the testing of CVC^2 from beginning to end. Computer simulations such as SIMNET offer a satisfactory method for proof of concept.

However, to properly test a new C2 system, humans must be added into the loop at all levels. Each leadership and duty position which stands to gain from an automated C2 system must be represented. A computer simulated environment does not sufficiently evaluate the commander's ability to control the chaos and uncertainty of the battlefield. Human interaction with "freeplay" that introduces the chaos and uncertainty must be permitted to "play itself out" in the evaluation. Only a field exercise with troops can create the true environment necessary to test CVC^2's ability to influence C2. CVC^2's testing and evaluation requires humans-in-the-loop at all levels, the ability for "freeplay" to influence chaos and uncertainty, an evaluation of extended duration, and appropriate measures to be considered as successful and complete.

B. ADVANTAGES

As with all new technologies, advantages and disadvantages arise with their introduction into a unit. One major advantage of CVC^2 is that it may allow the friendly commander to get within his opponent's C2 decision cycle. Ability to plan and react quicker enables the friendly commander to gain the "upper hand". The amount of time to plan and execute missions and to react to changes in those missions is greatly reduced through the acceleration of the commander's decision cycle time and increasing the

tempo of his operations. Other advantages of CVC^2 are the increase in message transmission speed, the clarity of that transmission, the accuracy of graphics and text included in the transmission, the flexibility it gives the unit commander, and the increase in situational awareness.

CVC^2 significantly increases the speed of message traffic and graphics dissemination to subordinate, adjacent, and higher units. The increase in transmission speed of intelligence summaries, operations orders, or logistical reports permits the friendly units more time to plan for or react to enemy activity. Communications traffic is also reduced because of the speed of digital burst message transmission. CVC^2 allows for a better plan and an automated process which therefore requires less command and control during the execution. This in turn leads to less time on the net, reducing the electronic signature.

Another advantage is the clarity of the transmitted messages. With CVC^2, one individual can transmit the message to all appropriate units and sections without having to rely on an operator to send the message over the radio and attempt to get acknowledgement from the receiving stations. Each receiving station would receive the same message.

The third advantage is the accuracy of the message. Prior to transmitting, the sender can verify the message, whether text or graphics, on his display for correctness.

If any correction is required, it can be quickly made. With the push of the send button, all designated units receive an accurate text or graphical display message. Situational awareness is now improved, thereby lifting some of the "fog of battle".

Flexibility is a fourth advantage. A commander can quickly send and receive reports and situational updates without having to wait for an opening on the voice radio net. He now has the ability to transmit information and intelligence to all subordinate units simultaneously or selectively. With this ability to rapidly reposition forces, he can swiftly alter previous orders to react to new battlefield situations. CVC^2 enhances the commander's ability to mass forces at the critical time and place.

CVC^2 increases the user's situational awareness of friendly and enemy locations. This in turn could lead to the reduction of potential fratricide.

C. DISADVANTAGES

One disadvantage to automated C2 from CVCC is the loss of face-to-face contact between a commander and his subordinate leaders. Talking directly to a junior leader permits the emphasis on certain aspects of an order, such as commander's intent. Face-to-face discussion alerts the commander to any problems that his subordinate may be having which is not discernible over the radio. Eliminating the

face-to-face opportunity, CVC^2 therefore reduces the commander's ability to exert real leadership.

Another disadvantage is the installation of CVC^2 into modern tanks and infantry fighting vehicles adds to an already technologically complicated system. The system will require operators to undergo additional training on its use and maintenance. Soldiers that service the equipment will also require special training since it is a computerized system. However, the components are fault-tolerant, easily expandable, and provide integrated diagnostics. Each component is standardized in all vehicles to ease the logistical burden.

A third disadvantage is the diversion of the leader from other tasks as he becomes preoccupied with the new C2 system. As the leader is engrossed in CVC^2 updates and orders validation, his entire C2 process slows down instead of speeding up. CVC^2 is an aid to the commander, not the solution to his C2 problems.

The fourth and fifth disadvantages revolve around the verification of taskings and updates. Potential confusion, the fourth disadvantage, can arise as to the origin of the unit's taskings. An order can be forwarded over the system without some method of control. Unsigned orders raise questions about their validity and origination. As the fifth disadvantage, time is then spent verifying the accuracy of the information updates and database in the

system and the validity of unsigned transmitted orders, slowing the C2 process down.

A final disadvantage is the increased traffic on the one radio net. Consolidating the three battalion nets onto one offers the potential for message backlog and delays. Even with digital data transmission, during the battle everyone will be trying to transmit at the same time. Leaders must understand when to send each message based upon its priority and appropriateness to the tactical situation.

D. ISSUES

With the automation of command and control, several new issues that did not previously exist with manual systems arise. The first is the preoccupation of the leader or staff officer with the automation instead of the battle. A leader can become too concerned with the data entries and not the current situation. CVC^2 is a tool to aid the leader in the execution of his duties and not the target of his entire focus.

CVC^2 must be developed with the ability to directly interact with other automated systems currently in use or planned for future procurement. The system designed for the battalion and below must be able to interface with brigade and higher command and control systems or administrative/logistical systems at the battalion level. A higher echelon command and control tool, Manuever Control

System (MCS) is being fielded for use at brigade through corps level. Without a direct automated interface between CVC^2 and MCS at either battalion or brigade level, the transaction will have to be done manually, negating any benefit of automation at both levels.

Interaction with other elements of the combined arms team within the Army and with other services outside of the Army must also be devised. A team is only as good as its slowest player and if elements of the combined arms team can not interface with CVC^2, then the entire team suffers from a slow C2 process. In the future, Army units can expect to execute joint operations with elements of other services. A CVC^2 equipped unit requires the ability to use its automated C2 system in the coordination of missions with the other service.

As more leaders gain the ability to update CVC^2's database, information overload, information redundancy, and information inaccuracies will occur. A prime example of this is the intelligence update or spot report. The same report, viewed from several locations, can be entered by several leaders, thereby rapidly filling up the database. Each leader sends a report on enemy activity whichs results in three reports on the same event. These reports may or may not reflect the same location for the enemy activity. Leaders at the various levels can monitor and aggregate the input to reduce the overload, redundancy, and inaccuracies,

but can easily become overcome themselves. An automated warning system needs to be created that provides a warning to the user entering the data that a report previously exists or conflicts with a different, existing entry.

A method must be designed to validate or "sign" the order to subordinate units. Without the subordinate leader's voice recognition of the senior officer and authentication procedures which are possible over current radios, acknowledgement as to the originator of an order is not possible over CVC^2. Questions then arise as to validity and time must be taken to determine the order's origin, thereby slowing the C2 process down and negating the benefit of an automated C2 system.

E. POTENTIAL

In the evaluation scenario tested at the National Training Center, the CVC^2 equipped battalion task force will outperform the non-CVC^2 equipped battalions. Both battalions are properly trained on small unit tactics and are proficient on individual fighting skills. Although the individual battalions' scout platoons might identify the enemy at the same moment, the task force with the automated C2 system will react quicker to the threat. Messages do not have to be relayed from one net to another as with voice systems. All stations receive the same message and graphics about the enemy. Having a status about friendly unit

locations and dispositions within the database, the commander can then issue orders without having to update all elements on the enemy situation. With a unit properly trained on CVC^2, and its standard operating procedures, issues such as information overload, diversion from the battle to update CVC^2, and message delays are avoided. In each of the established measures, CVC^2 equipped units will outperform the non-equipped units.

With CVC^2, all levels of command (crew, platoon, company, battalion) in all battlefield operating systems (fire support, intelligence, air defense, maneuver, mobility/survivability, command & control, combat service support) throughout all phases of battle the equipped units can be expected to perform quicker and with more accuracy than the non-equipped units.

Possible slowdowns for the equipped unit will occur when the soldiers are not familiar with or adequately trained on the new system. The CVC^2 unit will be engaging the enemy and reacting to its movements while the other battalions are still clarifying the situation and planning their own actions. As a result, the CVC^2 battalion task force will act quicker, retain its freedom of movement, destroy more of the enemy, suffer fewer casualties, and win the battle.

Advantages and disadvantages exist with each new system's introduction and use. Capitalizing on the

advantages and negating the disadvantages can be accomplished through the establishment of procedures and the training of leaders/users. Solving the issues that exist with CVC^2 will only increase its performance and ability to aid the commander. CVC^2 has demonstrated significant potential to reduce the commander's C2 decision cycle time. It will reduce the time required to plan and transmit reports which reduces the time required for the unit to act. This will permit the unit to gain an advantage in time and space over the enemy. Combat Vehicle Command and Control is an automated command and control system long overdue with great benefits to be gained by those U.S. forces using it.

APPENDIX: BATTALION TASK FORCE TRAINING & EVALUATION OUTLINES (T&EOs)

ELEMENT: BATTALION TASK FORCE

TASK: COMMAND and CONTROL the battalion task force (7-1-3901) (FM 71-2, FM 101-5)

ITERATION 1 2 3 4 5 (circle)

TRAINING STATUS T P U (circle)

CONDITION: The brigade issues an OPORD, warning order, or FRAGO.

TASK STANDARD:

a. The TF plan accomplishes the directed specified tasks IAW the brigade commander's concept and intent. The plan is received and understood by the leadership of the TF. It is coordinated with higher, adjacent, and supporting elements.

b. The TF is prepared to initiate the mission at the directed time.

c. The TF controls and synchronizes subordinate and supporting elements so that it accomplishes the mission and preserves the force.

d. The TF keeps higher, adjacent, subordinate, supporting, and supported headquarters informed.

SUBTASKS AND STANDARDS:	GO	NO-GO
+ *1. TF leaders issue the warning order.		
a. A complete warning order is issued within 15 minutes of receipt of the brigade order.		
b. Warning order is received by all platoons within 45 minutes of issuance of battalion warning order.		
***2. TF commander analyzes mission and gives initial guidance.**		
a. Guidance includes restated mission, which includes brigade commander's intent for the TF, and identifies all specified and implied tasks.		
b. Guidance includes instructions on information requirements and initially required preparation actions (movement, resupply) to start.		
c. Guidance is given within 30 minutes of receipt of brigade order.		
+3. TF accomplishes reconnaissance and other actions to gather needed information.		
a. Reconnaissance actions begin to physically gain information on the enemy and terrain as early as possible.		
b. Commander/subordinate leaders and staff conduct personal reconnaissance when possible. If not, the commander conducts a detailed map reconnaissance.		
c. Subordinate leaders conduct a personal reconnaissance when possible. See subordinate company and platoon T&EOs.		

*** Leader task**
+ Critical task

SUBTASKS AND STANDARDS:	GO	NO-GO
b. Disseminate and coordinate critical new information with higher, adjacent, and supporting headquarters.		
+ 9. TF executes changes in task organization.		
a. Main CP coordinates linkup location, time, and responsible element.		
b. Attachments/new elements are received at the coordinated location and time; updated on current situation, OPORDs, and SOIs; and resupplied.		
c. Detachments reach the linkup point at the time and place directed.		
+ 10. TF prepares, and commander and staff conduct, supervise, and monitor preparations.		
a. Commander conducts briefbacks with subordinate commanders, leaders, and key staff.		
b. Main CP maintains status of preparations.		
c. Elements make effective use of time to prepare for the operation.		
+ 11. TF sees the battlefield.		
a. Command group is positioned to see and move.		
b. Companies and other subordinates accurately report critical information on actions and changes in combat status within five minutes. See subordinate MTPs.		
c. Main CP collects, analyzes, and passes processed critical information.		
d. Subordinates execute intelligence collection plan.		
+ *12. TF leaders command and control the execution.		
a. Subordinate elements report enemy and friendly actions, change in status, and any other factor that would require change within three minutes.		
b. TF leaders win the battle by directing the maneuver of units, controlling direct and indirect fires, and directing other CS actions to cope with new METT-T factors. Indicators are: • Elements not following OPORD are corrected. • Responses to new METT-T are directed when new situation occurs. • No friendly casualties inflicted by friendly direct or indirect fires. • Number/percentage of direct fire weapons engaging enemy. • Number of indirect fire rounds fired and percentage hitting/suppressing the enemy. • Number of enemy casualties.		

*** Leader task**
+ Critical task

SUBTASKS AND STANDARDS:	GO	NO-GO
• Number of friendly casualties.		
c. Command and control, and CSS assets are controlled to support maneuver effort. Indicators are:		
• Effective CSS, and command and control.		
• Command and control or CSS element not destroyed by enemy direct fires.		
d. FRAGOs are clear, concise, and quickly executed by subordinates.		
e. Changes that affect the battle are disseminated within five minutes.		
+13. Subordinate commanders, leaders, and staff laterally coordinate actions during the battle.		
• All battle actions requiring coordination between battalion elements are laterally coordinated.		
+*14. TF coordinates with adjacent and supporting headquarters.		
• All battle actions requiring coordination with other headquarters are laterally and promptly coordinated.		
+15. TF reports.		
• TF CPs submit all critical and required reports to brigade. They report events to adjacent and supporting elements that impact on them in time for those units to react.		

TASK PERFORMANCE SUMMARY BLOCK						
ITERATION	1	2	3	4	5	TOTAL
TOTAL SUBTASKS AND STANDARDS EVALUATED						
TOTAL SUBTASKS AND STANDARDS "GO"						

No OPFOR tasks and standards.

*Leader task
+ Critical task

ELEMENT: BATTALION TASK FORCE/MAIN COMMAND POST

TASK: OPERATE main command post (7-1-3904) (FM 71-2, Chapter 2; FC 71-6)

ITERATION 1 2 3 4 5 (circle)

TRAINING STATUS T P U (circle)

CONDITION: The TF performs tactical operations and receives an OPORD, warning order, or FRAGO from brigade.

TASK STANDARD:

a. The main CP plans, coordinates, supervises, and communicates to ensure the successful accomplishment of the assigned mission.

b. The main CP submits required operational/ intelligence reports to the brigade IAW brigade SOP.

c. The main CP is not destroyed.

SUBTASKS AND STANDARDS:	GO	NO-GO
+1. Main CP moves and positions.		
a. CP survives.		
b. Main CP maintains communications with all required stations.		
***+2. Main CP issues warning orders.**		
• Issues a complete warning order to all subordinates and staff within 15 minutes of receipt of a brigade order or instructions from the TF commander to issue a new OPORD.		
***3. TF commander or main CP OIC analyzes mission.**		
a. Brigade and division commanders' intents are identified.		
b. All specified and implied tasks are identified.		
c. Commander is updated within five minutes if he is not located at main CP or aware of brigade order.		
***4. Main CP OIC collects or updates estimates.**		
a. S3, FSE, and combat trains CP provide current and accurate friendly status. Initial status is provided within 15 minutes. Completed estimates are available before commander's war gaming.		
b. S2 provides intelligence estimate, and situational and events templates before commander begins war gaming.		
***5. TF commander or main CP OIC gives initial guidance.**		
a. Restates mission, which includes brigade commanders intent for TF, and identifies all specified and implied tasks.		

***Leader task**
+ Critical task

SUBTASKS AND STANDARDS:	GO	NO-GO
b. Disseminates instructions on information requirements and initially required preparation actions (movement, resupply).		
c. Presents initial guidance within 30 minutes of receipt of order.		
***6. Main CP OIC issues FRAGOs implementing movement, reconnaissance, and other preparations.**		
• FRAGOs are issued to subordinates as soon as decisions are made to make maximum use of time.		
***7. Main CP OIC coordinates collection of additional information.**		
a. Staff collects all needed and available information from brigade, supporting elements, adjacent elements, and subordinates to update estimates.		
b. All information directed by the TF commander is collected.		
c. Information is available when the commander returns from reconnaissance and finishes war gaming.		
***8. TF commander and staff develop and war game courses of action and select one.**		
a. Tactically feasible and full courses of action (include CS as well as maneuver) are made and war gamed with the available staff. (The command group principles—commander, S3 and S2 representatives, and fire support representative—are best for quick-planning sequences; while the TF main CP principles—add the XO, engineer, ADA officer, S1, S4, FAC, and signal officer—are included in more deliberate situations.)		
b. Selected course of action accomplishes the mission and all directed tasks, and complies with the brigade commander's intent.		
c. Selected course of action is war gamed and refined by the commander and staff so the staff understands the concept, produces a sound OPORD, and rehearses the battle. The commander's concept and guidance for preparation of the order includes:		
• An intent (overall purpose and end result).		
• Designation of main effort (for each phase if shifting is envisioned).		
• A scheme of maneuver outlining missions, movement, and primary tasks of all combat elements through completion of mission.		
• A plan of fires outlining scheme, tasks, and priorities for fire support. Fire support execution matrix is used, when possible.		
• A plan for engineer support outlining missions, primary tasks, and priorities for attached or supporting engineers.		

*** Leader task**
+ Critical task

SUBTASKS AND STANDARDS:	GO	NO-GO
• Operations, primary tasks, and priorities for attached or supporting ADA, MI, or other CS elements.		
• Operations, primary tasks, and priorities for TF CSS.		
+*9. Main CP OIC and staff develop the OPORD from the commander's guidance.		
a. The OPORD complies with the commander's guidance.		
b. The OPORD is completed at time directed.		
+*10. TF commander or main CP OIC reviews, modifies, and approves the OPORD.		
• OPORD is concise and complete, and accomplishes the mission.		
***11. TF issues the OPORD/FRAGO/warning order.**		
a. OPORD/FRAGO/warning order is issued IAW one-third, two-thirds rule and makes full use of daylight time.		
b. OPORD/FRAGO/warning order accomplishes all directed missions and tasks, complies with the brigade commander's intent, and is doctrinally sound.		
c. All subordinate and supporting elements receive the OPORD.		
d. Brigade and adjacent units receive TF OPORD.		
e. OPORD issued with an annotated overlay.		
f. The OPORD has—		
• Task organization.		
• Mission.		
• Concept and intent for maneuver, supporting fires, and mobility, countermobility, and survivability.		
• Missions/tasks for each subordinate and fire support.		
• Coordinating instructions needed to synchronize the efforts of maneuver forces and combat support.		
• Necessary CSS instructions.		
g. If more time is available, a more developed OPORD is issued. (An initial FRAGO may be issued to allow subordinates to begin preparation.)		
h. Order is given at a location that reduces travel time, allows observation of the zone/sector, and promotes OPSEC.		
i. If time is available, the TF commander conducts briefbacks and war gaming immediately after the order to improve subordinate understanding and reaction.		

*** Leader task**
+ Critical task

SUBTASKS ANS STANDARDS:	GO	NO-GO
j. Subordinate leaders and staff should conduct lateral coordination before leaving the orders site.		
***12. TF XO and staff refine plans, coordinate and supervise preparation activities, and disseminate new information.**		
a. Time is used to continue gathering information and to improve the plan (develop contingency plans, refine fire plans).		
b. Critical new information is disseminated to the commander, staff, and subordinate/supporting headquarters.		
c. Preparation and combat status are kept current and accurately maintained (reconnaissance, construction of obstacles/survivability positions, resupply, maintenance, locations and actions of subordinate/supporting elements, movement).		
d. Preparation problems are identified, corrected, or coordinated with the appropriate element for correction.		
***13. Signal officer prepares a communication plan. The plan—**		
a. Provides for antijamming (alternate frequencies, code words).		
b. Coordinates issuance of SOIs.		
c. Provides for use of relays to maintain communications with subordinates.		
d. Recommends alternate means of communication for radios.		
***14. Main CP supports the command group command, control, and coordination of the battle. The main CP—**		
a. Issues FRAGOs for the commander.		
b. Analyzes and collates information from other nets, and keeps the commander updated by providing concise and consolidated updates.		
c. Coordinates with adjacent and supporting elements.		
d. Provides critical CS and CSS information to the commander from the field trains CP.		
e. Communicates to subordinates who the commander cannot reach.		
f. Coordinates additional support from brigade.		
g. Performs any action needed to support the commander fighting the battle.		
h. Coordinates the movement of the battalion mortars.		
i. Ensures FSE integrates mortars into battalion indirect fires.		

*** Leader task**
+ Critical task

SUBTASKS AND STANDARDS:	GO	NO-GO
+ 15. Main CP reports.		
a. Reports allow the brigade to follow the battle.		
b. Reports are accurate, follow prescribed formats, and submitted NLT time specified in OPORDs or SOPs.		

TASK PERFORMANCE SUMMARY BLOCK						
ITERATION	1	2	3	4	5	TOTAL
TOTAL SUBTASKS AND STANDARDS EVALUATED						
TOTAL SUBTASKS AND STANDARDS "GO"						

No OPFOR TASKS and STANDARDS.

*** Leader task**
+ Critical task

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